HONEYWELL

Technical Manual

MODEL A20B
DC AMPLIFIER
INSTRUCTION MANUAL

Honeywell

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DC AMPLIFIER
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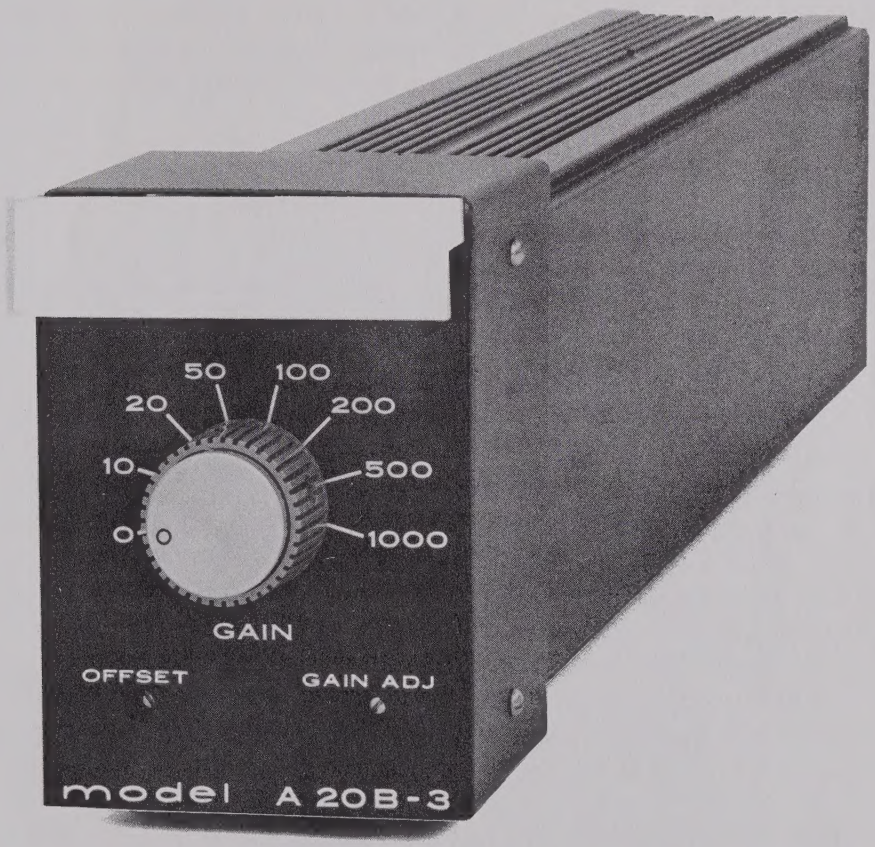

Model A20B-3 DC Amplifier

MODEL A20B DC AMPLIFIER

CHANGE NOTICE NO. 1

This change notice pertains to all Model A20B DC Amplifiers with serial numbers 1090031 and higher. Amplifiers with serial numbers below 1090031 are not affected.

Refer to Figure 4.2 in the basic manual. The physical positions of potentiometers R9 and R5 on the preamplifier board have been reversed. R9 is now closer to the rear of the amplifier and R5 is now closer to the front of the amplifier. The calibration procedure outlined in paragraph 4.3 in the basic manual has not been changed.

CHANGE NOTICE NO. 2

This change notice announces a new option, contains specification changes for the standard options, and list specifications for the new option.

Add the following paragraph:

"1.3.4 Gain Multiplier Option

"A gain multiplier option is available for use in combination with all standard options described in paragraph 1.3. The option consists of an input divider which is controlled by an additional switch. This switch (red knob) is concentric with the GAIN switch (black knob) and selects either a X1 or X.01 gain multiplier. In the X1 position, the amplifier is normal in all respects. In the X.01 position, the input divider is switched in to attenuate the signal on each input lead by 100:1. All amplifiers with a numeral 4 in the dash number are equipped with the gain multiplier option, i.e. Models A20B-14, A20B-24, and A20B-34.

"The input divider consists of four resistors with their center-tap connected to common (output LO). This use of an attenuator balanced to common increases the common-mode voltage and differential capabilities of the amplifier."

In paragraph 1.5 change the frequency response, input impedance, and overload recovery specifications to read as follows:

Frequency Response: (100 ohm minimum load)	±1% DC to 2 kc, 1 db to 20 kc, 3 db to 50 kc, 3 db to 100 kc for gains of x100 or less.

Input Impedance:	10 megohms minimum shunted by 200 pf maximum.
Overload Recovery:	Recovers to ±5 microvolts referred to input ±5 millivolts referred to output within 250 microseconds from a ±5 volt input overload.

Add the following paragraph:

"1.5.1 Specifications for the Gain Multiplier Option

"When the gain multiplier switch is set to X1, the amplifier specifications in paragraph 1.5 apply, and when the gain multiplier switch is set to X.01, the following specifications apply:

"Gain Accuracy:	Same as X1, except for sources up to 200 ohms differential or 100 ohms single-ended.
"Frequency Response: (100 ohm minimum load)	1% to 2 kc, 1 db to 20 kc, 3 db to 50 kc, all gain settings.
"Input Resistance:	2 megohms differential, 1 megohm either input to common (output LO).
"Maximum Input:	350 volts DC or peak AC combined signal and common mode voltage, either input lead.

CAUTION

Make certain that the gain multiplier switch is set to X.01 before applying an input voltage that exceeds 30 volts.

"Common Mode Rejection, DC to 60 cps, any gain setting:	66 db for balanced source, 50 db for 1 kilohm unbalance.
"Zero Drift: (45 minutes warmup)	
Constant ambient:	±500 microvolts referred to input or output, whichever is greater.
Coefficient per degree Centigrade:	±200 microvolts referred to input or output, whichever is greater.

"Noise Referred to Input: (gain settings of 100 or above):	
0 to 3 cps:	Not greater than 300 microvolts peak-to-peak.
1 kc:	Not greater than 150 microvolts rms.
Wideband:	Not greater than 750 microvolts rms.
"Noise Referred to Output: (gain settings of 50 and less)	
"Overload Recovery:	Output recovers to ±10 millivolts within 250 microseconds from a ±500% input overload.
"DC and AC Linearity:	Same as for X1, except gain settings of 50 and above. "

Add the following sub-paragraph at the end of paragraph 2.3.6:

"When the multiplier switch is set to X.01, the input divider provides the necessary input return, however, the guard shield has to be connected to the common mode source or common (output LO) for single-ended operation. "

Add the following sentence to the introductory sub-paragraph of paragraph 4.3:

"The gain multiplier switch of Models A20B-14, A20B-24, and A20B-34 must be set to X1 throughout calibration. "

Add the following sub-paragraph to paragraph 5.4.4:

"c. Gain accuracy of gain multiplier option:

"(1) Set the multiplier switch to X.01 and the GAIN switch to 100.

"(2) Short pin K to pin E (output LO), apply approximately 9.5 volts DC (either polarity) to pin J, and monitor the amplifier's input and output with a digital voltmeter. The magnitude of the output should equal the input within ±0.1%.

"(3) Short pin J to pin E, apply approximately 9.5 volts DC to pin K, and monitor the amplifier's input and output with a digital voltmeter. The magnitude of the output should equal the input within ±0.1%.

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SECTION I

DESCRIPTION

1.1 INTRODUCTION

The Model A20B is a solid-state, wide-band, DC amplifier featuring low noise, low drift, high stability, and accurate gain control. High DC input impedance prevents circuit loading when measuring from high impedance sources. The Model A20B may be used as a differential or single-ended, inverting or non-inverting amplifier. All choppers, mechanical and electronic, have been eliminated. (Patent applications are pending for the Model A20B DC Amplifier.)

1.2 FUNCTION

The Model A20B amplifies low-level DC and AC voltages, and provides proper impedance matching and isolation between the voltage source and subsequent equipment. It is particularly suitable for the amplification of transducer outputs in data acquisition systems in which differential or floating input requirements and common mode voltages are encountered.

1.3 EQUIPMENT DESCRIPTION

The Model A20B is contained in a compact module 3-1/2" high x 2-1/2" wide x 16-1/4" deep (overall depth). Six units can be mounted in a standard 19" rack. There are three standard gain options:

Option 1 (Model A20B-1) provides fixed gain steps only.

Option 2 (Model A20B-2) provides fixed gain steps and a screwdriver adjustment with a range ±2% about the nominal value.

Option 3 (Model A20B-3) provides fixed gain steps and a screwdriver adjustment with a range x1 to x2.5 upwards from the nominal value.

1.3.1 Front Panel Controls

The GAIN control (on all options) provides fixed gain steps of 0, 10, 20, 50, 100, 200, 500, and 1000. In position 0, the

output high lead is disconnected from the amplifier and connected, instead, to the output low. This position may be used to make zero or other adjustments to the load with no amplifier signal. It may also be used as a turn-on or a turn-off position to minimize transients to the load.

NOTE

The amplifier gains are the same for differential or single-ended operation, either polarity.

The OFFSET screwdriver adjustment (on all options) is adjusted to provide a zero output for a zero input on all gains. This adjustment is not intended to accommodate input signal offsets, however, it has sufficient range to compensate for small offsets. Clockwise movement produces a positive change in the output.

The GAIN ADJ screwdriver adjustment (not on option 1) provides variable gain ±2% from the fixed gain on option 2, and variable gain x1 to x2.5 upwards from the fixed gain on option 3. This adjustment maintains the same effect on all gain steps (both options). Clockwise movement increases the gain. On option 3, best performance is obtained with a settings near x1.

1.3.2 Mounting

Two housing units are available for the Model A20B DC Amplifier.

a. Rack mount Model A20-R houses up to six amplifiers. It is a standard rack 3-1/2" high x 19" wide x 20" deep. The rack is equipped with an AC power cable, power switch, power fuse, and pilot lamp. Filler panels are available when less than six amplifiers are mounted in the rack.

b. Portable case Model A20-C mounts a single amplifier.

1.3.3 Fuse Requirements

The amplifier has one internal fuse mounted on the power supply. A 1/10 ampere slo-blo fuse is used for 117 volts AC,

and a 1/20 ampere slo-blo fuse is used for 230 volts AC. The A20-R Rack is equipped with a 3/4 ampere slo-blo fuse for 117 volts AC, and a 3/8 ampere slo-blo fuse for 230 volts AC.

1.4 SPECIFICATION NOTATIONS

1.4.1 Effects of a Capacitive Load on Output Capability

A capacitive load has three principal effects on the output of the amplifier: (1) reduced bandwidth, (2) peaking in the frequency response, and (3) reduced output current at high frequencies for any other load. The slightly reduced bandwidth and peaking are caused by capacitive effects on internal response.

NOTE

The A20B output current is rated at 100 ma peak and the output voltage at 10 volts peak. These are independent limits equivalent to 70.7 ma rms and 7.07 volts rms, respectively.

The capacitive effects on the output current are more significant. For example, a 0.33 μfd capacitor at 10 kc has a reactive impedance of 50 ohms. Therefore, the maximum voltage across this capacitance at 10 kc is 0.07 amp x 50 ohms = 3.5 volts rms (or 4.9 volts peak). If this capacitor is shunted by a 100 ohm resistor, the load impedance (at 10 kc) is 45 ohms, the maximum output voltage is 3.2 volts rms, and the current in the load resistor is 32 ma rms (or 45 ma peak). Therefore, as cable capacitance and/or frequency are reduced, the current and voltage, available at the resistive load, are increased.

1.4.2 Common Mode Source

The direct coupling of the A20B requires that the input terminals have a DC return path to the amplifier common (output low). This consideration applies for both differential and common mode signals. The 100 megohm maximum specified is conservative and safe under any operating condition. In practice, a value as large as 1000 megohms or more is generally satisfactory.

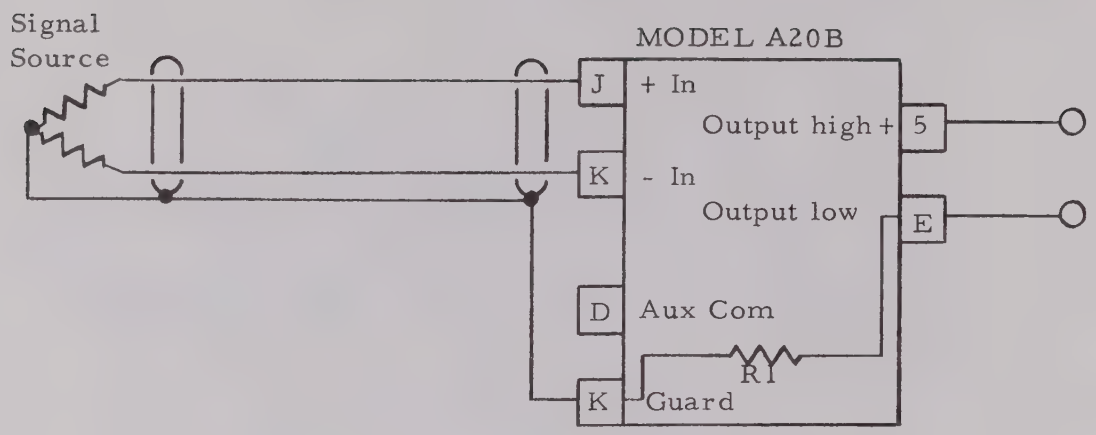


Figure 1.1. A20B With DC Return Through Internal Guard Resistor

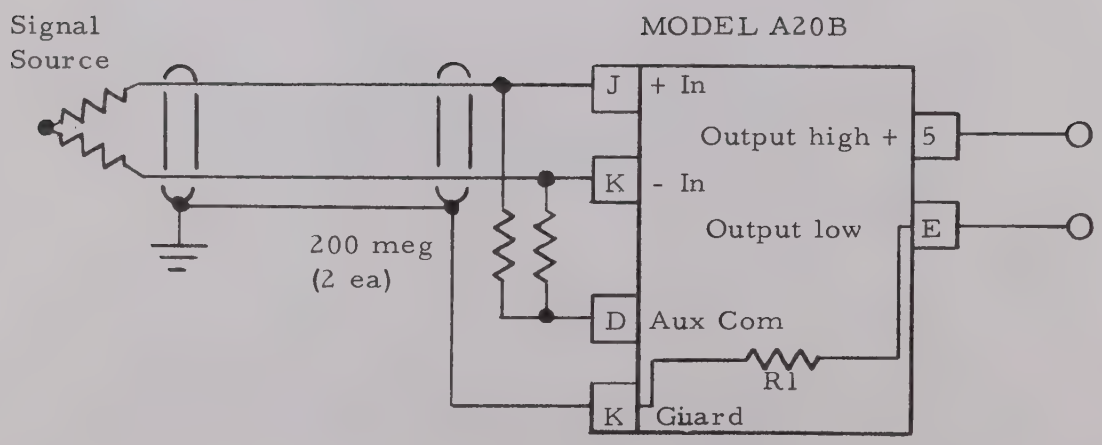


Figure 1.2. A20B Connected as a Balanced Differential Amplifier

The A20B has an internal guard resistor (R1, 20 megohms) connected between guard and output low. R1 may be used as the required input return if the source is floating (see figure 1.1).

NOTE

If the source is not floating, R1 merely shunts the common mode impedance. In the few applications where this shunting is not desired, R1 may be removed.

If the input shield must be grounded and it is desired to float the input at a high impedance, then connect equal resistors (200 megohms each) between auxiliary common and each input lead as shown in figure 1.2. In this case, the A20B acts similar to a balanced differential amplifier. Other amplifier connections are explained in paragraph 2.7 and illustrated in figure 2.2.

1.4.3 Settling Time

The rating specifies a return to zero condition. This method was chosen to facilitate measurement of settling time with basic test equipment. The amplifier is uniform in response regardless of polarity, whether returning to zero or rising to full scale. Uniformity is the same for both load and no-load conditions.

1.5 SPECIFICATIONS

These specifications apply for 0 to 1000 ohm signal sources in any unbalance, except as noted.

Output Capability:

Full scale voltage:	±10 volts DC or peak AC to 20 kc.
Load current:	±100 ma DC or peak AC to 20 kc.
Capacity loading:	0.33 μfd, all gain settings.
Output impedance:	0.2 ohm DC.

Linearity and AC Distortion:
(100 ohm minimum load)

DC:	±0.01% maximum.
AC:	DC slewing shift not more than ±0.01% of peak AC up to 2 kc.
Frequency Response: (100 ohm minimum load)	±1% DC to 2 kc, 1 db to 20 kc, 3 db to 50 kc.
Settling Time:	80 microseconds to within ±3 millivolts for return to zero from ±10 volts output.

Gain:

Fixed gain steps:	0 (output disconnected and grounded), 10, 20, 50, 100, 200, 500, and 1000.
Gain option 1:	Fixed steps only ±0.1% accuracy, ±0.01% stability for ±5°C ambient charge.
Gain option 2:	Fixed steps plus a ±2% panel vernier, 0.5% resolution (worst case), ±0.01% stability for ±5°C ambient change. Step ratio accuracy ±0.1%.
Gain option 3:	Fixed steps plus a variable gain control with a range of x1 to x2.5, at least 0.5% resolution, and ±0.25% stability. Gain accuracy for control at maximum CCW is ±1%, with a step ratio accuracy of ±0.1%. (Specifications apply for x1 settings only.)

Input:

Common mode voltage:	±12 volts (±15 volts at normal line and higher) DC or peak AC to 400 cps.
Input signal return:	No ground return needed when guard is connected to signal source (normal case), otherwise limit is 100 megohms.
Input impedance:	10 megohms minimum shunted by 750 pf maximum.

Signal source:	Specifications apply in any unbalance up to 1 kilohm (except as noted), stable with 50 kilohms in any unbalance.	
Common mode rejection:		
DC to 60 cps:	Balanced source: 3200 times the gain (130 db at a gain of 1000).	
	350 ohm unbalance: 2000 times the gain (126 db at a gain of 1000).	
	1 kilohm unbalance: 1000 times the gain (120 db at a gain of 1000).	
400 cps:	1 kilohm unbalance: 200 times the gain (106 db at a gain of 1000).	
Zero Drift: (45 minutes warmup)		
Constant ambient:	±2.5 microvolts referred to input, or ±500 microvolts referred to output, whichever is greater.	
Coefficient per degree Centigrade:	±1.0 microvolts referred to input, or ±200 microvolts referred to output, whichever is greater.	
Noise Referred to Input:	Gain of 1000	Gain of 100
0 to 3 cps:	2.0 microvolts peak-to-peak.	3.0 microvolts peak-to-peak.
1 kc:	0.8 microvolts rms.	1.2 microvolts rms.
Wideband:	3.5 microvolts rms.	6.0 microvolts rms.
Noise Referred to Output: (gains of 50 and less)	0.5 millivolts rms, wideband.	
Overload Recovery:	Recovers ±5 microvolts referred to input ±5 millivolts referred to output with 500 microseconds from a ±5 volt input overload.	

Temperature Range:	0^{o} to $+50^{o}$C for specified performance, $+60^{o}$C for safe operation, -25^{o}C to $+85^{o}$C storage.
Safe Inputs:	
Common mode voltage:	±30 volts DC or peak AC.
Differential input:	±15 volts DC or peak AC continuously, ±40 volts for transients, has diode limiter.
Short Circuit Protection:	Safe under all conditions, no output fuse; maximum output current approximately 130 ma.
Power Requirements:	Nominal line 117 volts AC, 50 to 400 cps, approximately 2 volt-amperes no signal, specifications apply for range of 105 to 125 volts AC; may be strapped for 230 volts AC ±10% operation. Maximum line input 5 volt-amperes, any condition.
Line Regulation:	±10% line voltage change causes less than ±1 millivolt output change.
Dimensions:	16-1/4" (41.3 cm) overall length x 3-1/2" (8.89 cm) high x 2-1/2" (6.35 cm) wide.
Net Weight:	Approximately 4-1/2 lbs (1.93 kg).

SECTION II

OPERATION

2.1 INSPECTION

After being unpacked, the equipment should be inspected for shipping damage. If damage is found, an immediate report should be made to the shipping agency and to Honeywell Inc. If equipment fails to operate as specified, check all connectors, cables, and fuses. Should equipment fail to operate satisfactorily during the warranty period, follow the procedure outlined in the warranty page of this manual.

2.2 PRECAUTIONS

Damage may result if the differential input exceeds ±15 volts DC or peak AC. The input circuit is protected by a diode limiter which will permit transient voltages up to ±40 volts peak.

The common-mode voltage should not exceed ±30 volts DC or peak AC.

Care should be exercised during cable installation to insure that the connector key is in place. If this key is removed from the connector, it is possible to make an inverted connection. Such a connection would cause considerable damage to the amplifier when AC power is applied.

2.3 INSTALLATION AND CABLING

2.3.1 Connectors

Each Model A20-R Rack is fitted with six 20-pin connectors, and each of these connectors receive a plug-in amplifier. Single amplifiers and amplifiers in the portable case are each provided with one of these connectors. Table 2.1 lists the function of each connector pin and figure 2.1 illustrates input, output, and power connections. Each rack mount is provided with the AC power wiring.

2.3.2 Complete Cable Assembly (See Figure 2.1)

A complete cable assembly is available as a standard option. This assembly provides all necessary connections for operating the amplifier. The assembly is particularly suited for testing single amplifiers or single amplifier applications. Input and output cables are provided with convenient plug connectors and the input shield has a separate lead and clip for flexibility in guard connections. A lead connected to auxiliary common is also assembled with the input cable. Auxiliary common may be used as a convenience lead in maintaining the input ground return or for common mode rejection tests as a common.

Table 2.1 Connector Pin Functions

PIN	FUNCTION	PIN	FUNCTION
A	AC line, low (white cable).	1	AC line, high (black cable).
B	Conduit common (power ground, green cable).	2	Chassis (amplifier case).
C	Key (no electrical connection).	3	Key (no electrical connection).
D	Auxiliary common (recommended for grounding one input in single-ended operation, see paragraph 2.3.7).	4	Spare.
E	Output Low	5	Output High.
F	Spare	6	Spare.
H	Input Guard	7	Strapped*
J	Input No. 1 (see paragraph 2.3.7).	8	Strapped*
K	Input No. 2 (see paragraph 2.3.7).	9	Strapped*
L	Strapped*	10	Strapped*

*Pins 7, 8, 9, 10, and L are internally strapped to pin H (input guard).

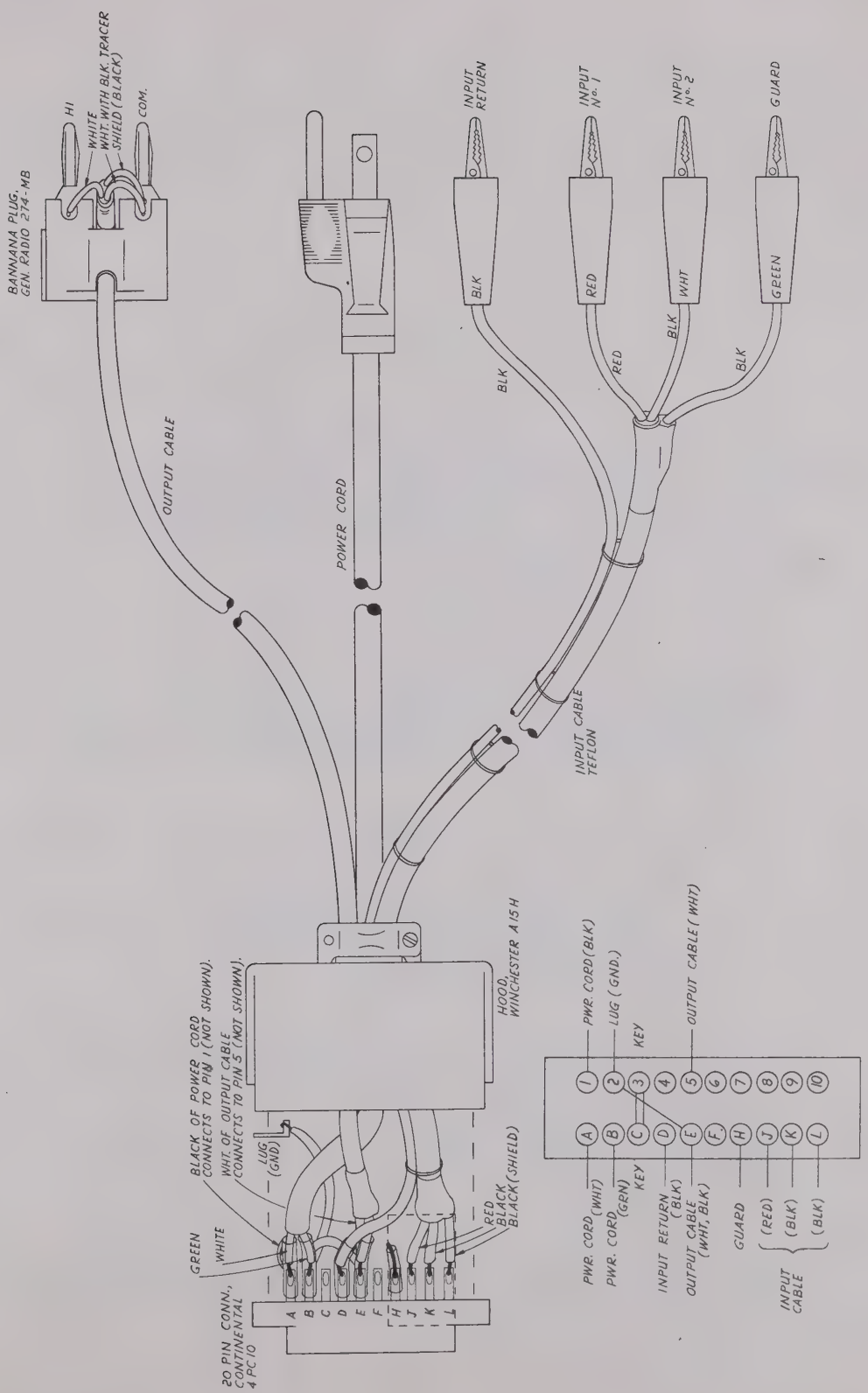


Figure 2.1. Input, Output, and Power Connections

2.3.3 Partial Cable Assembly

A partial cable assembly is available as a standard option. It provides only the power line wiring as shown in figure 2.1. This assembly may be used for patching into test cables without intervening plug connectors and associate shielding.

2.3.4 Input Wiring

To realize the very high common mode rejection of the Model A20B, it is essential that external wiring is properly installed. Stray capacitance, as low as 1 μfd, will cause a significant loss in rejection at 60 cps and higher frequencies. Therefore, it is important that all connections to the input circuit are well shielded and the shield is driven by the common mode voltage. At the amplifier, the shield should be maintained as close to the connector pins as possible. Good shielding also helps to minimize noise pickup.

2.3.5 Amplifier Stabilization

Except for the small warmup drift, the Model A20B is ready for operation immediately after applying power. For most rapid stabilization, the input circuit should be terminated as follows:

a. The two input leads must be resistively connected (50 kilohms or less).

b. At least one input lead must have a resistive return (100 megohms or less) to output low or auxiliary common.

Open input terminals cause internal overloading which adversely affects stabilization. Drift stabilization is not affected by gain setting or output loading.

AC power can be applied to the amplifier continuously without affecting its life.

2.3.6 Amplifier Grounding

The amplifier circuitry is isolated from the case and the AC power line. However, sufficient stray coupling exists to cause

a finite current (generally less than 2μa) from output low to power ground. To prevent this current from adding to common mode signals, it is recommended that output low be grounded at some point in the system. If DC isolation is desired, a capacitor (0.1μfd or larger) may be used for this grounding.

CAUTION

The maximum DC or peak AC potential between chassis and output low is limited to 30 volts.

2.3.7 Circuit Configurations

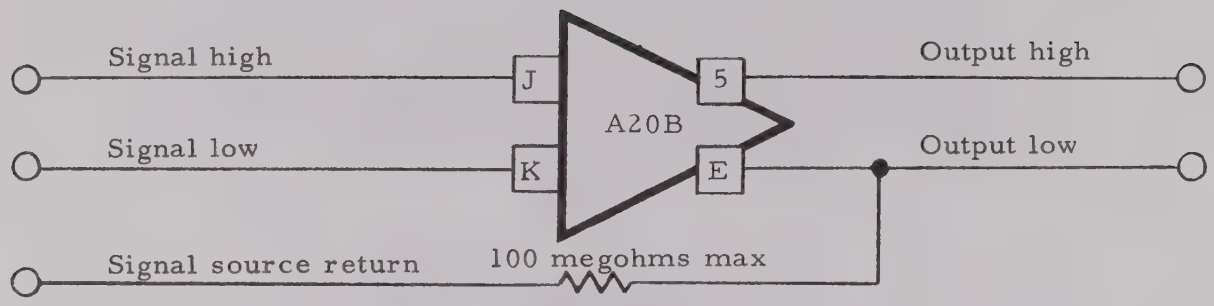
The Model A20B may be used as a differential or single-ended, inverting or non-inverting amplifier. Figure 2.2 illustrates the connections for differential (i.e. four-terminal) and single-ended (three-terminal) operations. The input terminals have a fixed relative polarity to the output regardless of mode of operation. For example, with pin J positive relative to pin K, the output at pin 5 will be positive relative to pin E. This holds true for a differential input, single-ended non-inverting input (pin K grounded), or single-ended inverting input (pin J grounded). Other configurations are explained in paragraph 1.4.2 and illustrated in figures 1.1 and 1.2.

NOTE

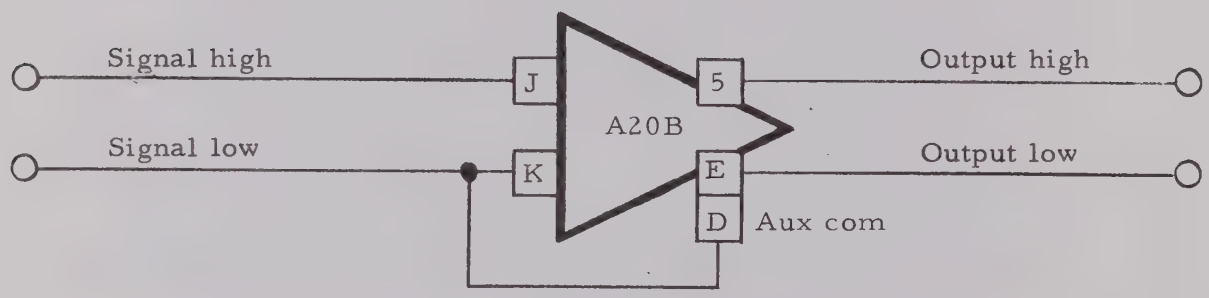
For single-ended operation, a slight increase in performance is obtained by grounding the selected input lead to the auxiliary common instead of the output low.

2.3.8 Galvanometer Applications (See Figure 2.3)

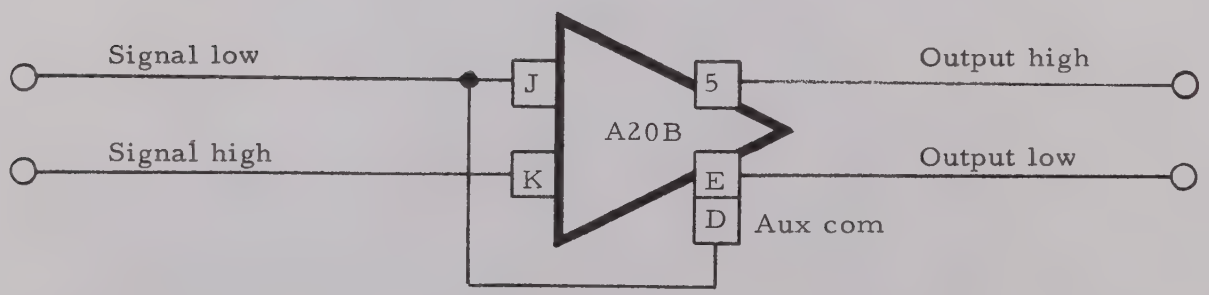
Generally the internal resistance of galvanometers is low, 25 ohms is a typical value. In this case, series resistance should be added to make the galvanometer full scale correspond to the amplifier full scale (10 volts on the A20B). This increases accuracy, because galvanometers are sensitive to current, and the series resistance makes the amplifier more of a current source. If the galvanometer requires a particular driving



a. Differential

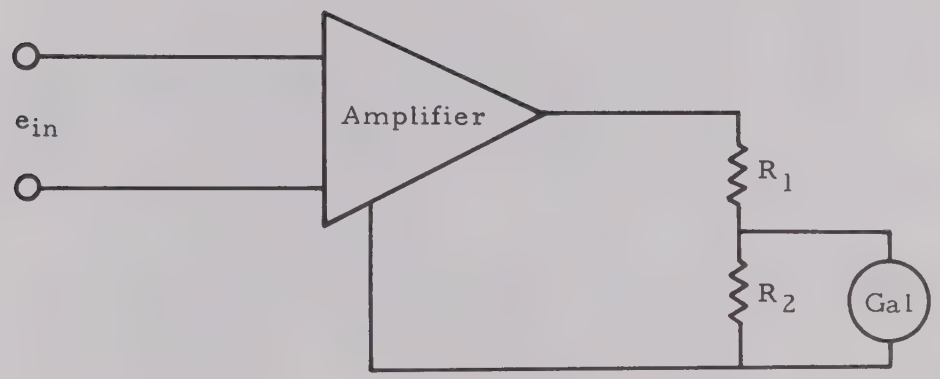


b. Single-Ended Non-Inverting



c. Single-Ended Inverting

Figure 2.2. Model A20B Circuit Connections



$$R_1 = \frac{10V}{I_{fs}\left(1 + \frac{R_g}{R_d}\right)}$$

$$R_2 = \frac{R_1 R_d}{R_1 - R_d}$$

Where: R_d = Required external damping resistance

R_g = Galvanometer resistance

I_{fs} = Galvanometer full scale current

Figure 2.3 Galvanometer Resistor Network

resistance, such as an external damping resistance, a two-resistor network is needed between the amplifier and its load. This resistance network helps protect the galvanometer from overload.

2.4 OPERATIONAL CHECK AND PROCEDURE

2.4.1 Option 1

a. Set the GAIN control to 0.

b. Apply AC power and while the amplifier is warming up (refer to paragraph 2.3.5) proceed with the next step.

c. With the GAIN control set to 0, zero the load (galvanometer, etc.).

d. Set the GAIN control to the fixed gain desired.

e. At the signal source (normal operational source), establish a zero signal for the amplifier's input. With a zero signal into the amplifier, adjust the OFFSET for a zero reading at the load.

f. At the signal source, establish a known signal (full scale calibrate signal) for the amplifier's input. Note the full scale reading at the load. The amplifier is ready for normal operation.

2.4.2 Options 2 and 3

Perform steps a. through d. of paragraph 2.4.1 and proceed as follows:

a. At the signal source (normal operational source), establish a zero signal for the amplifier's input. With a zero signal into the amplifier, adjust the OFFSET for a zero reading at the load.

b. At the signal source, establish a known signal (full scale calibrate signal) for the amplifier's input. Trim the GAIN ADJ for a full scale reading on the load.

c. (Option 3 only). Repeat steps a. and b. (this paragraph) to eliminate any interaction. The amplifier is ready for normal operation.

SECTION III

THEORY OF OPERATION

3.1 INTRODUCTION

The Model A20B DC Amplifier is designed for use as a differential or single-ended amplifier. It features low noise, high stability, and accurate gain control. High DC input impedance prevents circuit loading when measuring from high impedance sources. All choppers, mechanical and electronic, have been eliminated, and DC gain is achieved by the use of all direct-coupled stages. The amplifier's all solid-state circuits are located on three circuit boards: the output amplifier board (main amplifier board), the preamplifier board, and the power supply board.

The discussion that follows pertains to all options, unless otherwise stated.

3.2 ABBREVIATIONS

The following abbreviations are used in this manual.

ABBREVIATION	TERM
MAB	Main Amplifier Board
PAB	Preamplifier Board
PSB	Power Supply Board
CMV	Common Mode Voltage (or Signal)
CMR	Common Mode Rejection
MMV	Normal Mode Voltage (or Signal)
CMA	Common Mode (Output) Amplifier
CMRA	Common Mode Reference Amplifier
CLA	Current Limiting Amplifier

CMV is defined as the average input, relative to common. CMR is expressed as the db ratio of CMV to the equivalent input it causes.

$$CMR = \frac{CMV \times Gain}{CM_{output}}$$

NMV is defined as the differential input or internal signal.

3.3 PRINCIPLE OF OPERATION (See Figure 3.1)

The A20B consists of four differential stages, a common mode amplifier, a common mode reference amplifier, an output amplifier, a current limiting amplifier, and a power supply. The output amplifier and its associated current limiting amplifier are located on the MAB, and the power supply is located on the PSB. All other circuits, including the principal feedback resistors (R37 through R40) are located on the preamplifier board.

Common mode rejection without shielded transformers is achieved by guarding the differential stages and all connected impedances at the common mode voltage. By definition, the CMV is the average of the two input levels at any instant. Driving all input circuitry near the CMV, effectively raises the input impedance for common mode signals to a high value. Thus input currents for common mode signals are reduced nearly to zero and high CMR is maintained even with unbalanced sources.

Two systems are used in the A20B to reduce the effects of common mode voltage. The first is a unity-gain amplifier (CMRA) which samples the CMV at the emitters of the first differential pair and drives the entier preamplifier system at the CMV. The second is a high gain feedback system consisting of the four differential stages and the common mode amplifier. This feedback loop provides additional input impedance to the CMV, maintains proper DC operating levels for the differential stages, absorbs feedback currents, and drives the feedback bridge (R37 through R40). These nearly independent systems provide a floating power supply (i.e. at the CMV) for the differential stages and unity gain for common mode signals while the differential stages provide high gain for the desired normal mode signal.

The CMV is finally rejected in the fourth differential stage where the NMV is also converted from differential to single-ended. The output amplifier provides additional gain, and the required output voltage and current. Overall amplifier gain is established by the feedback and gain set circuits.

Maximum differential signals are limited by a diode bridge and load connected directly across the input leads. The bridge operates as a full-wave rectifier for excessive signals, shunting current into another diode which functions as a load. This load

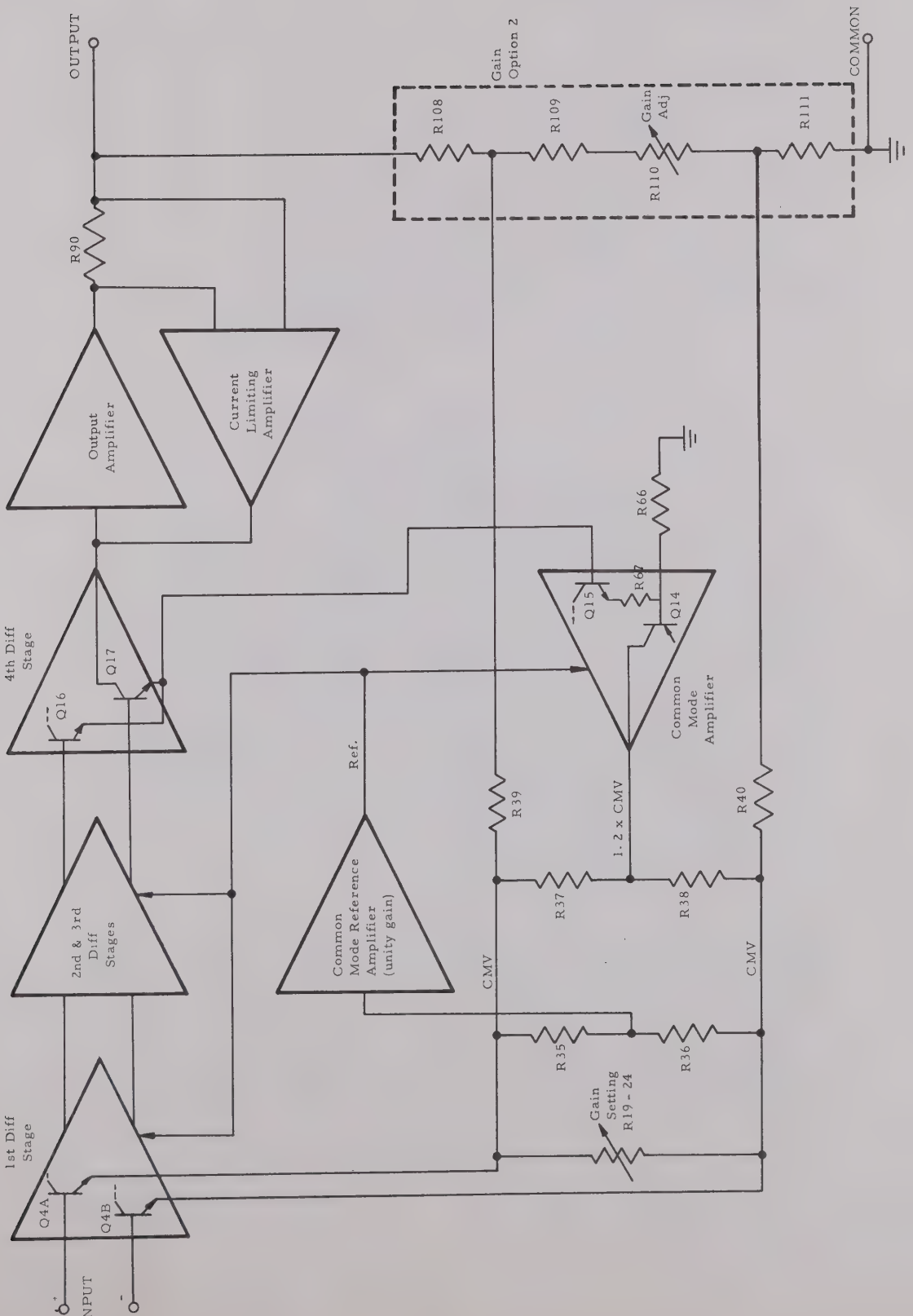


Figure 3.1. A20B Block Diagram

diode is biased to insure that no clipping action occurs for signals of normal amplitudes. To prevent drift effects, special low leakage diodes are used in the bridge.

The current limiting amplifier has been designed primarily to protect the load (such as a galvanometer); it also protects the amplifier. A cross-coupled balanced amplifier samples the voltage developed across a current sampling resistor in series with the output line. As the current increases in either polarity, the balanced amplifier develops a feedback signal which reduces the output drive. The limiting circuit is designed to provide sharp limiting at the desired level, yet permits no interference to normal signals just below the absolute limit level. The limiting current value is established by a single resistance value which for special requirements can be set to give a lower limit-current.

3.3.1 Common Mode Reference Amplifier (See Figure 3.2)

The input stages (1st differential stage) operates as emitter followers for the common mode reference amplifier. Two equal resistors, R35 and R36, in the emitter circuits of the input stages provide a driving point equal to the CMV. Following the resistor junction are cascaded complementary emitter followers (Q6 and Q8) with transistor current sources (Q7 and Q32). The high current gain of this combination and the relatively light loading, insure that the input impedance is high and that the CMRA output (Ref.) closely follows the CMV, even at high frequencies. Zener diode CR6, in series with positive current source I_1, functions as a floating battery to supply regulated voltage to the first three differential stages. Another emitter follower Q9, driven by CR6, regulates the currents of the common mode amplifier (CMA).

3.3.2 1st, 2nd, and 3rd Differential Stages

These stages operate at fixed low DC levels independent of the CMV by virtue of the reference driver (CMRA). Components in the 1st and 2nd stages are carefully matched for DC characteristics and are operated at low voltage and current levels to minimize drift. Overall thermally-dependent drifts and initial voltage offsets are compensated for by resistive elements in the emitter circuits of the 1st differential stage.

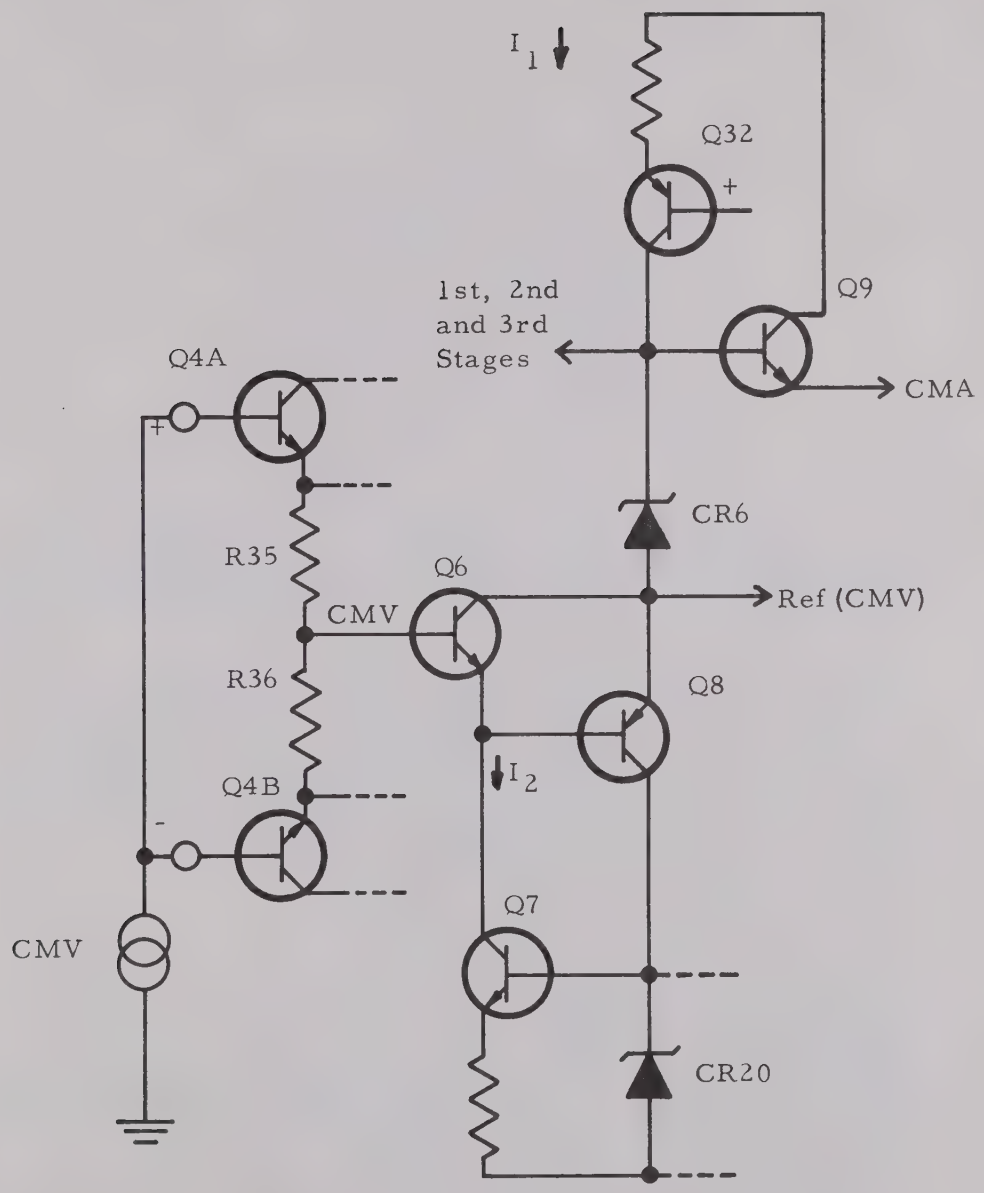


Figure 3.2. Common Mode Reference Amplifier

These elements (fixed resistors, thermally coupled temperature sensitive resistors, and trimmers) are chosen during factory calibration.

NOTE

R25, R26, R32, and R33 are selected on test, and in theory, the value of one or all of these components could be zero. Generally, the components in a given emitter are set to zero. For example: R25 and R26 could be replaced by a jumper. Resistors R28 and R34 which are also selected on test, will have values other than zero.

High frequency gain for the amplifier is accurately established by feedback paths around the 2nd and 3rd differential stages. These feedback circuits also provide most of the stabilization required in the common mode loop.

Base current for the 1st differential stage is provided by a three stage amplifier (Q1, Q2, and Q3). This amplifier has an output which varies with temperature approximately as the requirement for base current varies. Adjustable trimmer (R5 and R9) and large series resistors convert the amplifier output to the base current for the 1st differential pair.

3.3.3 4th Differential Stage

The CMV is finally rejected in the 4th stage and the differential signal is converted to a single ended signal for final amplification in the output amplifier. By holding the CMV to a gain of one and greatly amplifying the NMV, the differential stages in conjunction with the common mode amplifier have increased the ratio of the desired signal (NMV) to the undesired signal (CMV). Any lack of common mode rejection in the 4th stage causes a negligible equivalent input effect.

3.3.4 Common Mode Amplifier Loop (See Figure 3.3)

This loop consists of the four differential stages and the common mode amplifier. Unlike the CMRA which is mainly a

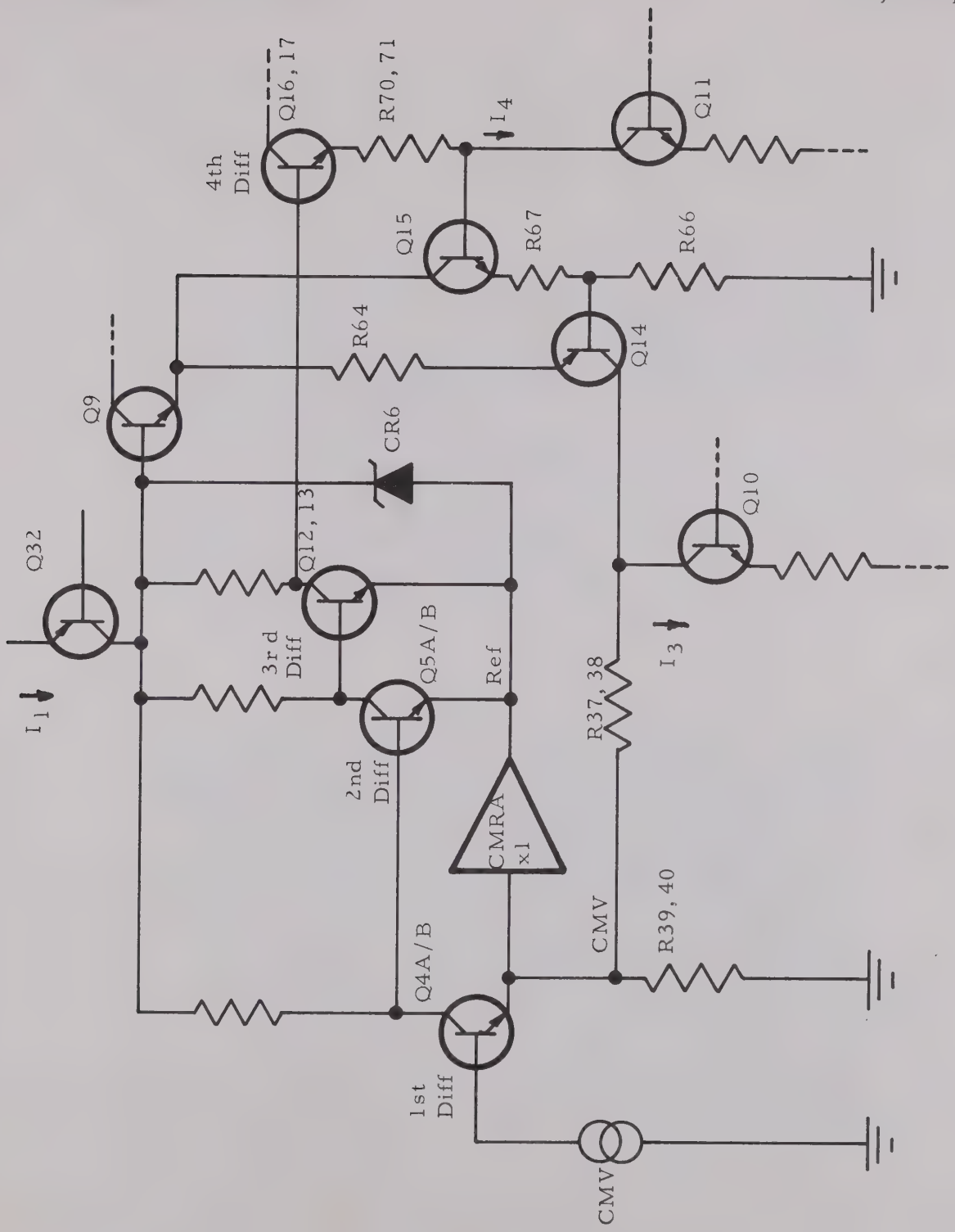


Figure 3.3. Common Mode Amplifier Loop

series of emitter followers, this is a multi-stage, high gain, feedback amplifier. In this loop, the differential stages each perform as parallel connected stages. The first three provide voltage gain and the fourth functions as an emitter follower driving the output section (CMA). The common mode amplifier consists of another emitter follower (Q15) and a final voltage amplifier (Q14).

Output of the CMA is fed back to the input emitters by means of the feedback bridge (R37 and R40). Transistors Q32, Q10, and Q11 are current sources and Q9 is a buffer stage. The CMA loop stabilizes the DC operating conditions of the first three differential stages and it increases the already high common mode input impedance. Q14, last stage of the CMA, also absorbs feedback currents due to normal mode signals. As the amplifier moves with the CMV, the output of Q14 swings considerably. This could result in large swings in the 3rd differential stage. To avoid this a resistor divider connected to common and the base of Q14 forces the required current change in Q14 without the necessity of a large signal from the preceeding stages.

3.3.5 Output Amplifier

The output amplifier consists of one high gain, high voltage swing stage (Q19) with a current source load (Q20), and several emitter followers (Q18 and Q21 through Q24). Emitter follower Q18 provides isolation between the preamplifier and the output amplifier. Signals amplified by Q19 are applied to emitter followers Q21 and Q22. Low current signals are routed through R79 and R80 to the amplifier's output. Outputs from Q21 and Q22 are also used to drive emitter followers Q23 and Q24 which conduct when higher currents are required.

A local feedback loop serves to control the frequency response, lower output impedance, reduce distortion, and reduce the effects of capacity loading. Part of the feedback (DC to 20 kc) is applied through resistors R96 and R97, and transistors Q26 and Q28. (Q26 and Q28 are also part of the current limiting amplifier.) Feedback for high frequency signals (above 16 kc) is through R85 and C16.

3.3.6 Current Limiting Amplifier

The current limiting amplifier consists of several stages, Q25 and Q31 which are normally not conducting, and Q26, Q28, Q29, and Q30 which are normally conducting. Transistor Q27 provides operating current for these transistors through isolating resistors R93 and R99. Q26 and Q30 operates as a differential pair which is diode cross-coupled at the emitters. Collector Q26 is the principal feedback means for normal and overload signals. Emitters Q26 and Q30 are current driven from the collectors of Q28 and Q29 which have grounded bases. This circuit arrangement avoids effects caused by changes in power supply voltages.

Transistors Q25 and Q31 are connected across current sampling resistors R89 and R90. As current becomes excessive in either polarity, one of these transistors will conduct (Q25 for positive overload, Q31 for negative overload) and its collector voltage is diode coupled to the differential pair. The current change that results, opposes the driving signal at base Q18 and abrupt limiting occurs.

3.3.7 Feedback Bridge (See Figure 3.1)

The feedback and gain set circuit establishes the overall amplifier gain. This circuit is arranged as a symmetrical, well-balanced bridge to achieve high common mode rejection. Precise balance prevents the common mode amplifier from inducing an erroneous differential signal between the emitters of the 1st differential stage. Such erroneous signals would affect the amplifier's output and cause a reduction in common mode rejection.

Gain selection is accomplished by resistors switched (by S1A) between the emitters of the 1st differential stage. A second divider (three options seen on the detailed schematic) across the output, introduce an additional 5% gain increase. This gain is fixed for option 1 and variable in options 2 and 3. Gain selections and adjustments are symmetrical with respect to the bridge. Therefore, gain changes do not influence bridge balance, and hence common mode rejection.

As the overall gain is changed, the internal gain of the amplifier is also changed. This is accomplished by S1B which varies the differential emitter degeneration in the third stage.

3.3.8 Power Supply

The power supply furnishes unregulated voltages to the amplifier. ±30 volts is used for all circuits except the high current output (Q21 through Q24) which is supplied with ±18 volts.

SECTION IV

CALIBRATION

4.1 GENERAL

Calibration of the Model A20B consists of adjusting three internal trimmers and the front panel OFFSET trimmer for proper DC balance. One internal trimmer and the OFFSET are adjusted to reduce the DC offset with a shorted input. The other internal trimmers reduce the offset effects of an unbalanced source resistance by adjusting the base currents of the 1st differential stage.

4.2 CALIBRATION EQUIPMENT REQUIREMENTS

a. Oscilloscope with minimum DC sensitivity 1 mv/cm.

b. Improvised test fixture as illustrated in figure 4.1. The 1 kilohm resistor and its associated switching must be shielded as shown. The Model A20-T Test Fixture, available on special order, may be used in lieu of the improvised set up. The A20-T may also be used for the amplifier checks outlined in Section V.

c. Output filter as illustrated in figure 4.1. Care should be used with the filter to prevent hum pickup. Use resistors with 5% tolerance and capacitors with 10% tolerance.

NOTE

CMR position of S2, 1 kc and Wide-Band positions of S3, and the oscillator are used in the amplifier tests outlined in paragraph 5.4.

4.3 CALIBRATION PROCEDURE

Calibration should be performed prior to the amplifier checks outlined in paragraph 5.4 and subsequent to any corrective maintenance. The GAIN ADJ on option 3 models should be set to x1 (fully CCW). Remove the amplifier from its case (see paragraph 5.2). Refer to figure 4.2 to locate the following adjustments on the PAB: R28, R5, and R9. Proceed as follows:

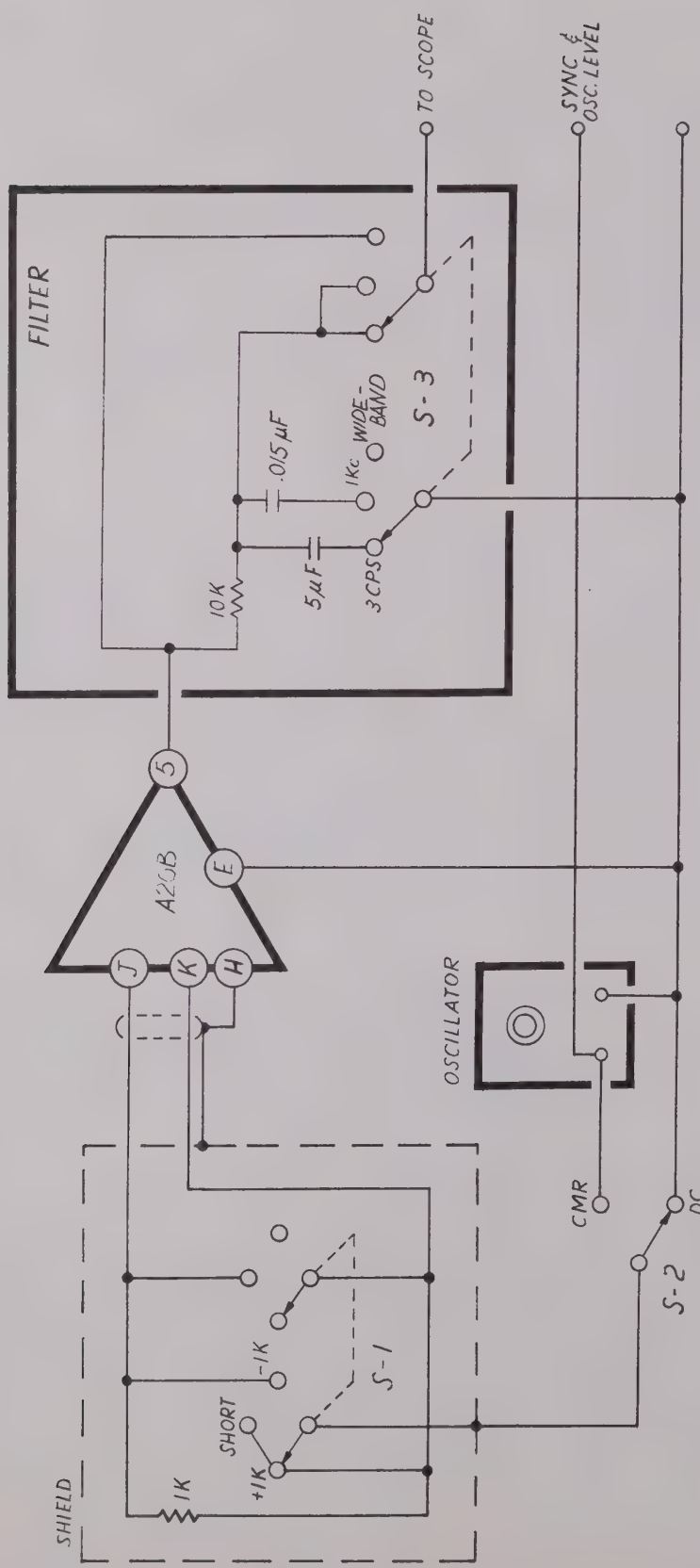


Figure 4.1. Improvised Test Fixture and Filter

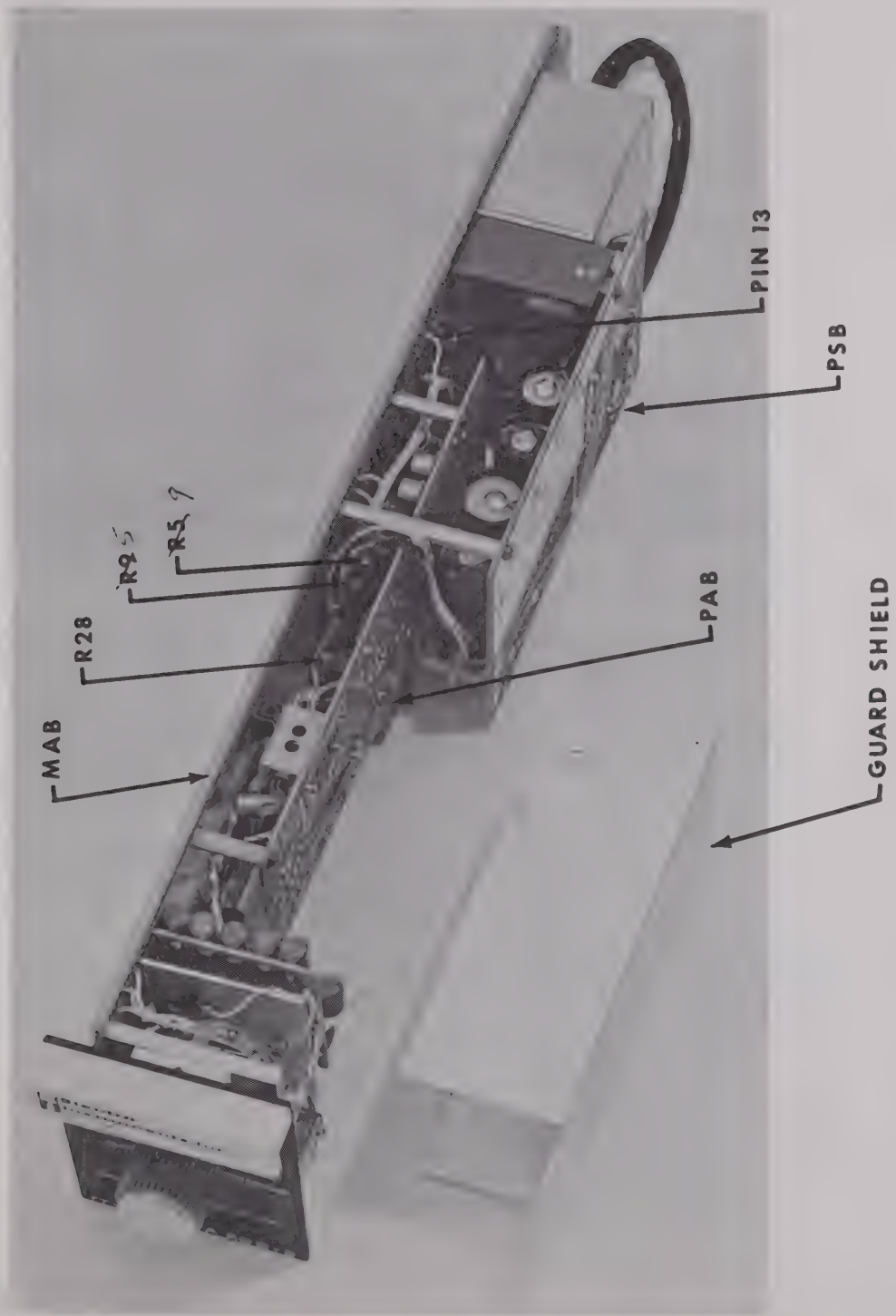


Figure 4.2. Location of Calibration Components

a. Set the test fixture switch S1 to SHORT, the DC-CMR switch S2 to DC, and the filter switch S3 to 3 cps. Allow the amplifier several minutes warmup time.

NOTE

Air currents introduce temperature gradients not normally present in the amplifier case. During calibration, the guard shield should be in place and the amplifier covered with a cloth to block air currents.

b. Set the amplifier GAIN control to x1000 and adjust R28 for a xero output. (Use the oscilloscope as a DC voltmeter in these tests.)

c. Set the GAIN control to x10 and adjust the panel OFFSET for a zero output.

d. Repeat steps b. and c. until the output is zero ±1 millivolt at gains x10 and x1000.

e. Set the GAIN control to x1000 and set S1 to SHORT. Note the output level.

f. Set S1 to +1K and adjust R5 as close as possible to the level obtained in step e. above.

g. Set S1 to -1K and adjust R9 as close as possible to the level obtained in step e. above.

h. Repeat steps f. and g. until switching between SHORT, +1K, and -1K changes less than 1 millivolt.

This completes the calibration procedure.

CAUTION

Take care when replacing the amplifier in its case — do not scrape or pinch the wiring. Be certain to replace all screws and do not overtighten.

SECTION V

MAINTENANCE

5.1 PERIODIC MAINTENANCE

The Model A20B requires no periodic maintenance. The amplifier can be operated continuously without any adverse effect on its life.

5.2 DISASSEMBLY

5.2.1 Hand Carry Models

Hand carry amplifiers are held in the amplifier case by two screws. One is located on the top of the case and one at the bottom, both about four inches from the rear panel. After removing the screws, slide the amplifier forward out of its case. If these screws are lost, replace only with 4-40 x 3/16" flat heads.

CAUTION

Take care when replacing the amplifier in its case — do not scrape or pinch the wiring. Be certain to replace both screws and do not overtighten.

5.2.2 Rack Models

Rack mounted amplifiers have one additional 4-40 x 3/16" flat head screw. It is located at the top of the case, just after the front panel. Upon reassembly, be certain to replace all three screws and heed the CAUTION notice in paragraph 5.2.1.

5.3 USE OF 230 VOLT POWER SOURCE

A 230 volt AC power source may be used by the Model A20B providing jumper changes are made on the power supply board. Figure 5.1 shows the primary of power transformer T1 connected for a 117 volt source and figure 5.2 shows the primary of T1 connected for a 230 volt source. To accomplish this change, the following steps are required:

a. Remove all power from the amplifier.

b. Remove the amplifier from its case (paragraph 5.2).

c. Examine the exposed side of the PSB and locate pins T1, T1A, T2A, and T2.

d. Gain access to the component side of the PSB by removing four screws; do not break any electrical connections between the PSB and the MAB.

e. Remove the jumper between pins T1 and T1A, and the jumper between pins T2A and T2.

f. Install a jumper between pins T1A and T2A.

g. Place a 1/20 ampere slo-blo fuse in the fuse receptacle.

h. Secure the PSB by replacing the four holding screws.

i. Use care to replace the amplifier in its case.

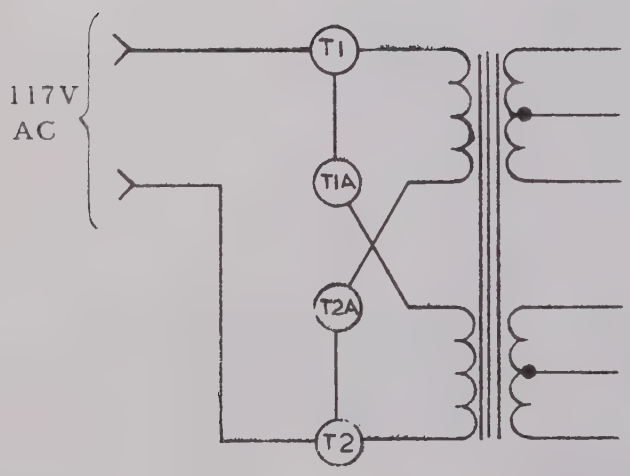


Figure 5.1.
117 Volt Connection

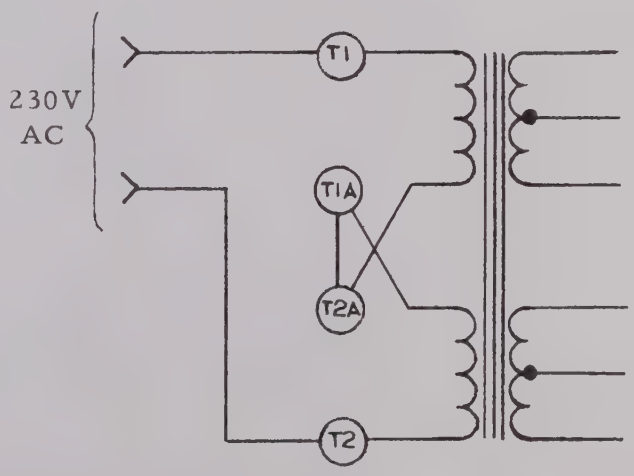


Figure 5.2.
230 Volt Connection

5.4 TEST PROCEDURE

Several tests may be used to determine that the amplifier performs as specified. These tests should be performed after the amplifier has been calibrated. In the event a malfunction is detected during test or calibration, reference should be made to paragraph 5.5. Performance of these tests will be an aid to trouble analysis. If any component changes are made in the amplifier, re-calibration is required.

In all tests the A20B is connected as a single-ended, non-inverting amplifier. Test conclusions are also valid for differential and inverting amplifier configurations.

When measuring gains of x100 or more, grounding is very important for high accuracy. In this respect, test setups should be followed closely. Also, stray capacity coupling from output to input is regenerative and may have adverse effects, e. g. cause the amplifier to oscillate.

The GAIN ADJ on option 3 models should be set to x1 (fully CCW).

5.4.1 Test Equipment Requirements.

a. Calibration equipment outlined in paragraph 4.2.

b. Oscillator, 60 cps minimum frequency, at least 30 volts peak-to-peak output, and maximum output impedance of 1000 ohms, such as Hewlett Packard Model 200CD.

c. Ratio transformer, accurate to approximately 0.001% such as Gertch Model RT-60.

d. Double shielded, 1:1 transformer with minimum primary inductance of 50 henries at 60 cps and 1 volt, such as Triad G24.

e. Average-detecting meter with minimum frequency response from 20 cps to 1 mc and at least 1 millivolt full scale sensitivity, such as Hewlett Packard Model 400D.

f. Broadband attenuator (db), such as Kay Electric Model 31-0.

g. DC voltmeter, such as Simpson Model 260.

A special test fixture, Model A20-T, is available on order for calibration and testing of the Model A20B Amplifier. Use of the A20-T simplifies test procedures and reduces the need for some items of equipment. Complete test instructions are furnished with the Model A20-T.

5.4.2 Output Noise Level

a. Connect the amplifier to the improvised test fixture and filter as illustrated in figure 4.1 and explained in paragraph 4.2. Set S2 on the test fixture to DC.

b. Set the amplifier GAIN and test fixture switches (S1 and S3) as indicated in table 5.1 for each measurement.

c. Measure the output noise level for each setting as indicated in table 5.1. Peak-to-peak measurements for the 3 cps position of S3 should be made with the oscilloscope. Rms measurements for the remaining positions (1 kc and Wide-Band) of S3 should be made with the average-detecting voltmeter.

d. Output noise should not exceed the values given in table 5.1. If noise levels are exceeded, refer to table 5.3, step 1.

Table 5.1 Maximum Output Noise Levels

AMPLIFIER GAIN	S1	S3		
		3 cps	1 kc	Wide-Band
x1000	+1K & -1K	2.0 mv p-p	0.8 mv rms	3.5 mv rms
x100	+1K & -1K	0.3 mv p-p	0.12 mv rms	0.6 mv rms
x50	+1K & -1K	---	---	< 0.5 mv rms

5.4.3 Common Mode Rejection

a. Continue with the test setup used in paragraph 5.4.2.

b. At the test fixture, set S2 to CMR and set S3 to 1 kc.

c. Set the amplifier GAIN and S1 on the test fixture as indicated in table 5.2 for each measurement.

d. Set the oscillator output at 30 volts peak-to-peak with frequency as indicated in table 5.2.

e. Use the oscilloscope to measure the peak-to-peak output of the amplifier. Outputs should not exceed the values given in table 5.2. If values are exceeded, refer to table 5.3, step 2. Typical output values are generally lower than those listed in table 5.2).

Table 5.2. Maximum Common Mode Output

AMPLIFIER GAIN	S1	Oscillator Frequency	
		60 cps	400 cps
x1000	SHORT	15 mv p-p	90 mv p-p
x1000	+1K & -1K	30 mv p-p	180 mv p-p
x100	SHORT	15 mv p-p	90 mv p-p
x100	+1K & -1K	30 mv p-p	180 mv p-p
x10	SHORT	15 mv p-p	90 mv p-p
x10	+1K & -1K	30 mv p-p	180 mv p-p

5.4.4 Gain Accuracy

a. Gain accuracy at low frequencies:

(1) Interconnect the amplifier, oscillator, ratio transformer (RT), oscilloscope, and 1:1 transformer (T1) as illustrated in figure 5.3.

(2) Set the oscillator output at 20 volts peak-to-peak, 100 cps. Set the amplifier GAIN to x10 and set the ratio transformer to approximately 0.1000.

NOTE

Checks at 100 cps are valid for all lower frequencies, including DC.

(3) Adjust R1 and the ratio transformer to obtain the best null (horizontal line) on the oscilloscope.

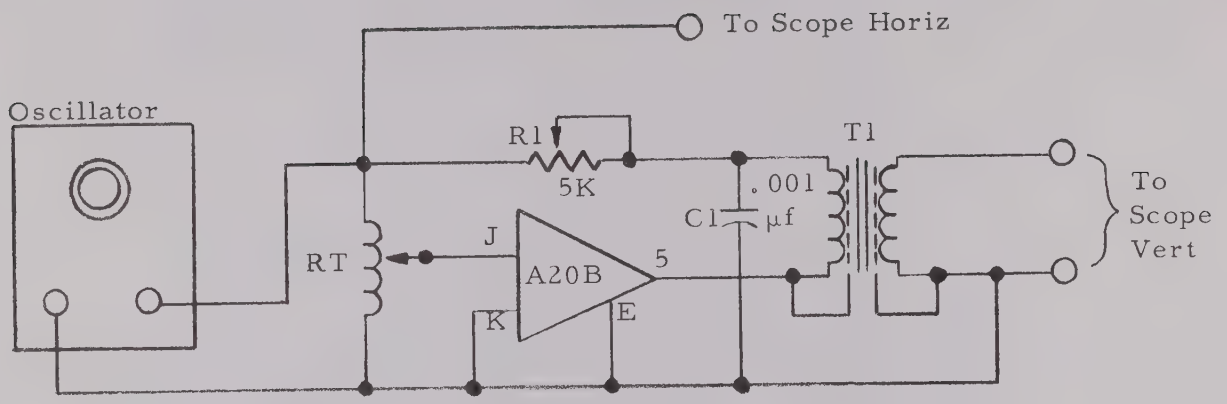
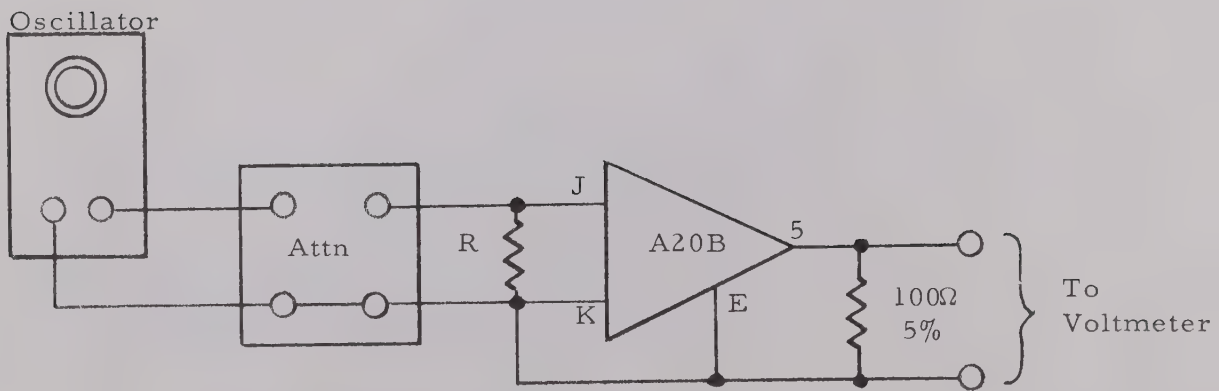


Figure 5.3. Gain Accuracy Test Setup



R = appropriate termination resistance.

Figure 5.4. Bandwidth Test Setup

(4) Read gain as the reciprocal of the ratio transformer reading.

Example:

$$\text{Gain} = \frac{1}{0.1001} = 10.01 \text{ or } +0.1\%$$

NOTE

On option 2 and 3 models, set the front panel GAIN ADJ to obtain the best gain accuracy. Gains obtained in this low frequency check as compared to gains obtained in the high frequency check that follows (para. b.) should meet the frequency response specifications outlined in paragraph 1.5.

(5) Repeat the above procedure for all GAIN settings of the amplifier.

NOTE

Since R1 and C1 also introduce amplitude error, the exact gain is given by:

$$\text{Gain} = \frac{1}{\text{RT reading}} \times \frac{1}{\sqrt{1 + (2\pi f R1\ C1)^2}}$$

However, for frequencies up to 2 kc the error due to R1 and C1 are negligible and gain may be determined as in step (4).

b. Gain accuracy at high frequencies:

(1) Repeat the same steps used in a., but set the oscillator frequency to 2 kc (20 volts p-p). Check all GAIN settings as before.

Gain accuracies at high and low frequencies should be within the limits specified for each option in paragraph 1.5. If excessive gain errors are encountered, refer to table 5.3, step 3.

5.4.5 Bandwidth Check

a. Interconnect the amplifier, oscillator, db attenuator, and average detecting voltmeter as illustrated in figure 5.4.

b. Set the amplifier GAIN to x10, the attenuator to 20 db, and the oscillator frequency to 10 kc.

c. Adjust oscillator amplitude to obtain approximately 0.75 volt rms on the voltmeter. Select a convenient 0 db reference level on the voltmeter.

d. Increase the frequency, until the meter indication drops 3 db below the selected reference level. Note the frequency.

e. Repeat the above procedure for amplifier GAINS of x100 and x1000 with the attenuator set at 40 db and 60 db respectively. Note the frequencies.

f. The noted frequencies in all GAIN settings should be 50 kc or higher. If this frequency is not obtained, refer to table 5.3, step 4.

5.4.6 Output Capabilities

a. DC (voltage and current):

(1) Interconnect the amplifier, variable DC source, DC voltmeter, oscilloscope as illustrated in figure 5.5. Set the line adjust to provide 105 volts AC power to the amplifier.

(2) Set the amplifier GAIN to x10.

(3) The oscilloscope should be AC coupled and set to line sync. Observe the output noise level on the oscilloscope.

(4) Adjust the DC input (set for positive input) until there is an abrupt hum increase in the noise. Read the DC level on the DC voltmeter. It must be greater than 10 volts.

(5) Repeat the above procedure with a negative DC input. Level on the DC voltmeter must be greater than 10 volts.

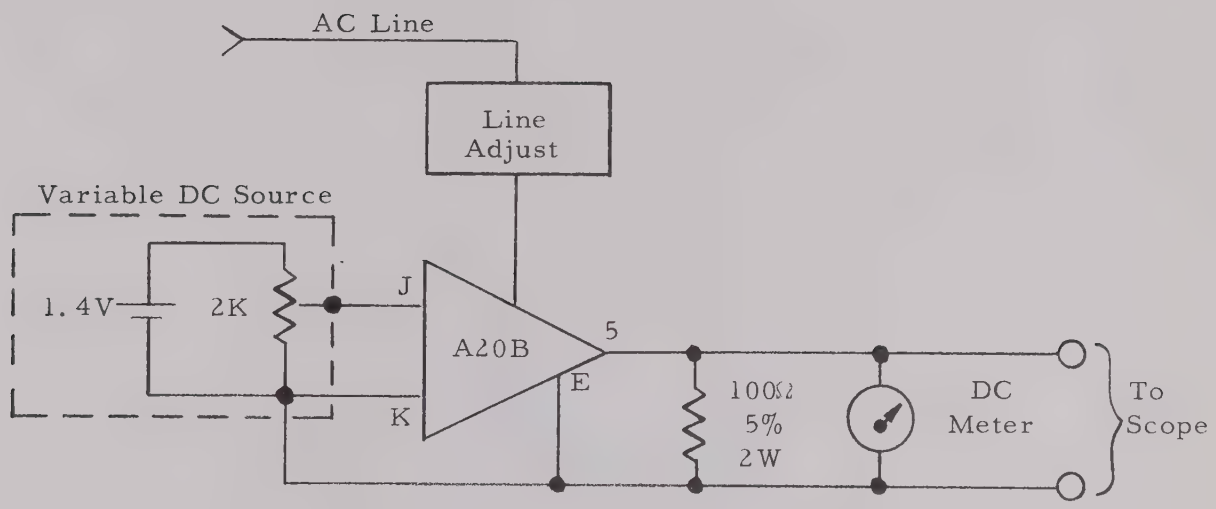


Figure 5.5. DC Output Test Setup

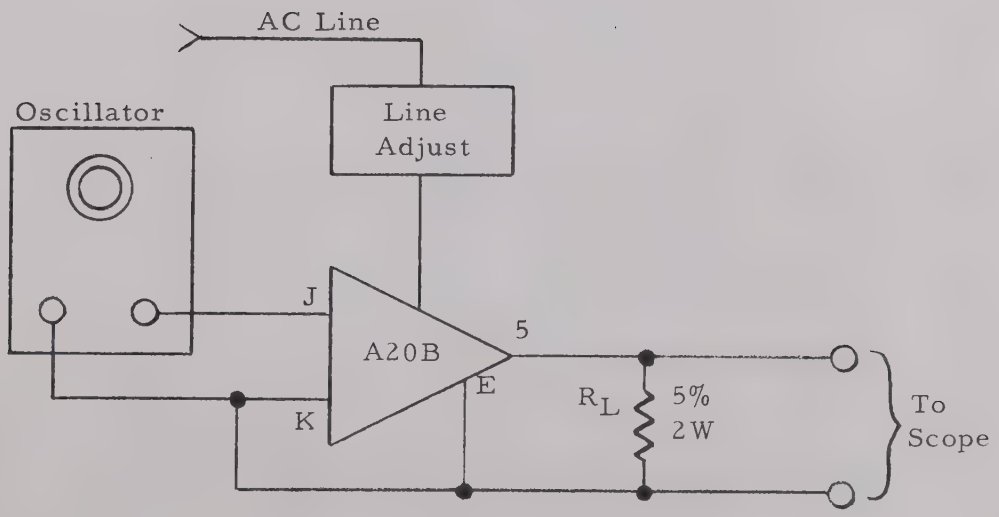


Figure 5.6. 20 kc and Current Limiting Test Setup

(6) If the DC output level is less than 10 volts, refer to table 5.3, step 5.

b. 20 kc (voltage and current):

(1) Interconnect the amplifier, oscillator, and oscilloscope as illustrated in figure 5.6. Set the line adjust to provide 105 volts AC power to the amplifier.

(2) Set the amplifier GAIN to x10.

(3) The value of load resistor R_L should be 100 ohms, and the oscillator frequency should be set at 20 kc.

(4) Observe the amplifier's output (sinewave) on the oscilloscope. Increase the oscillator output until the sinewave on the scope is distorted.

(5) At distortion, the sinewave should be greater than 20 volts peak-to-peak. If not, refer to table 5.3, step 5.

c. Current Limiting:

Specifications for current limiting are not listed in paragraph 1.5. However, this test checks the performance of the output circuitry and ensures load protection.

(1) Repeat steps b.(1) and b.(2).

(2) The value of load resistor R_L should be 10 ohms, and the oscillator frequency should be set at 500 cps.

(3) Increase the oscillator output until the waveform on the oscilloscope approximates a square wave. The peak-to-peak level of this waveform should be greater than 2.3 volts and less than 2.8 volts. If not, refer to table 5.3, step 6.

5.5 CORRECTIVE MAINTENANCE

In the event of malfunction, normal troubleshooting techniques should be adopted. All plugs, leads, connectors, power supply voltages, and the fuse should be carefully checked.

5.5.1 Guidelines

a. As an aid to trouble analysis, key voltages have been listed on the detailed schematic. These voltages are for nominal AC line (117V or 230V), amplifier input shorted and returned to output low (pin E), and for all gains. Most voltages are accurate to ±5%. Measurements must be made with a high impedance voltmeter.

b. When making DC voltage checks, observe proper polarity.

c. When checking zener diodes use correct voltage and polarity.

d. V_{BE} is approximately 0.6 volt for an "on" transistor. Excessive voltage should be "suspect".

e. Each amplifier is tested and calibrated prior to shipment. With this in mind, the following assumptions should be made in troubleshooting:

(1) The amplifier is wired correctly.

(2) Transistor troubles are usually limited to: open, short, and noisy.

(3) Diode failures are: open and shorted.

(4) Resistors become open or increase in value.

(5) Capacitors can be open or shorted.

5.5.2 General Precautions

a. Troubleshooting the preamplifier board should be delayed until it has been determined that the malfunction is not elsewhere (see paragraph 5.5.4). Component changes may require special recalibration and handling the PAB can cause a reduction in high impedance values. Individual tests are used to select some components on this board and others are closely matched pairs.

b. Exact transistor replacements should be made when possible. Commercial replacements might provide adequate operation.

c. Precision resistors (1%) and zener diodes (5%) should be replaced with identical components.

d. High current is available throughout the amplifier circuitry. Care should be exercised while testing the amplifier to prevent damage to the transistors.

5.5.3 Symptoms and Remedies

Table 5.3 contains a list of symptoms, probable causes, and suggested remedies. These are given as general guides to possible trouble that might arise after the amplifier has given long periods of satisfactory operation. Steps 1 through 6 in table 5.3 are primarily related to any adverse conditions encountered while performing the checks outlined in paragraph 5.4.

5.5.4 Isolating Trouble To One Board

Most troubles on the PAB or the MAB can be isolated to the individual board by following the procedure below.

a. Insure that the power supply voltages (±18V and ±30V) are correct at the output of the PSB.

b. Remove all power from the amplifier and locate a white wire connected between pin 13 on the PAB and pin 13 on MAB. Unsolder this wire at pin 13 on the MAB (see figure 4.1).

c. Connect a 30 kilohm variable resistor (use a 20 kilohm fixed resistor in series with a 10 kilohm pot) between pin 13 on the MAB and output common (pin E, Table 2.1).

d. Connect the amplifier through the test output filter (paragraph 4.2c) to the oscilloscope. Set the filter switch S2 to the 3 cps position.

e. Restore power to the amplifier.

f. While observing the amplifier DC output on the oscilloscope, slowly vary the test resistance (10 kilohm pot). The amplifier output should track smoothly through zero, and be capable of swinging full scale in both the positive and negative directions.

If the amplifier does not meet the requirements in step f., the trouble is probable on the MAB, otherwise the trouble is probable on the PAB.

Table 5.3 Troubleshooting Guide

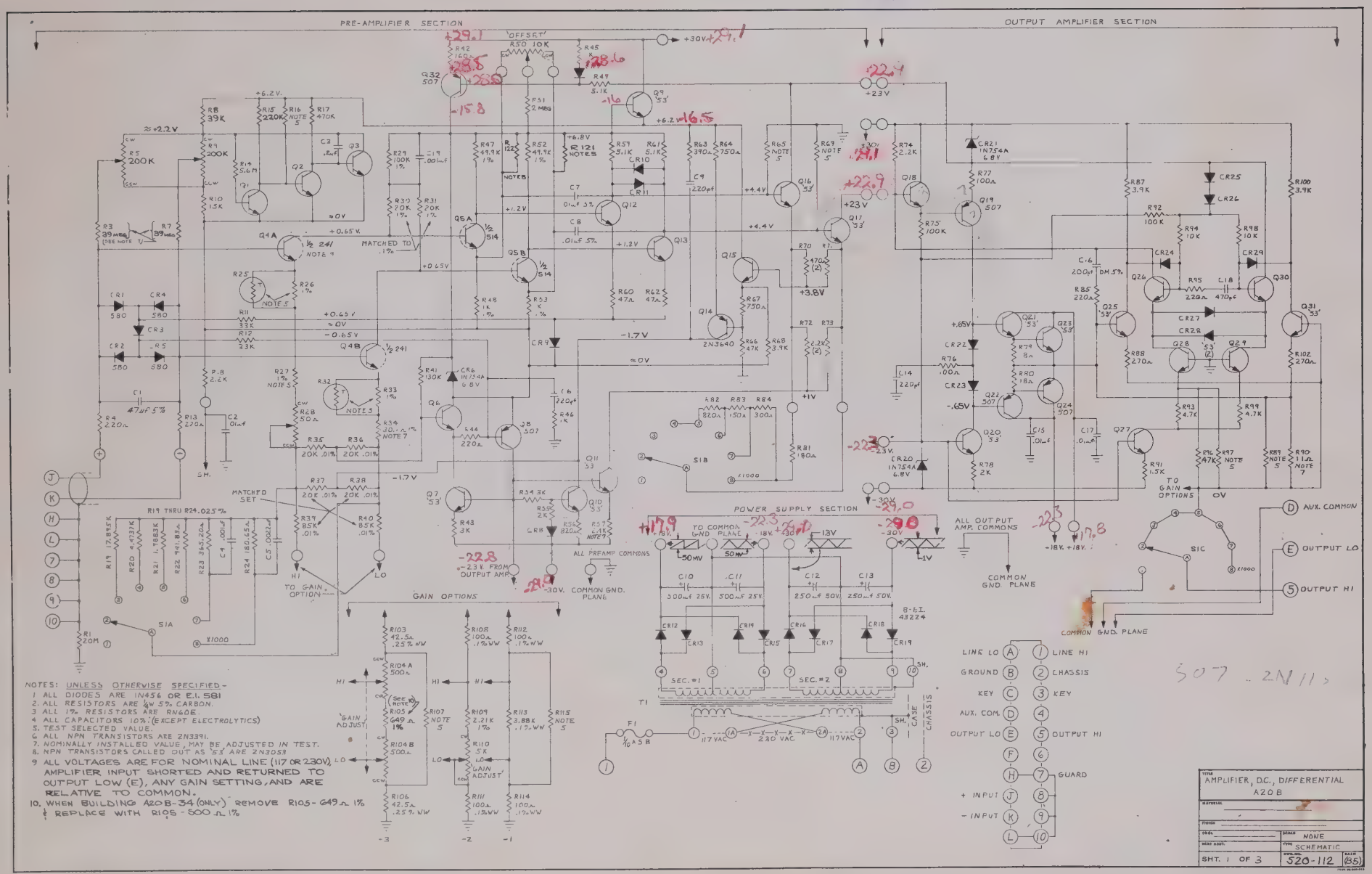
Symptom	Probable Cause	Suggested Remedy
1. Excessive Noise:		
a. 60 cps noise.	a. Inadequate shielding of amplifier input or test output filter.	a. Check test setup for proper shielding and grounding.
b. 120 cps noise.	b. Defective power supplies.	b. Check PSB for proper filtering.
c. Random noise.	c. Fault on PAB.	c. Check solder connections, check for intermittent resistors by probing and tapping, check board cleanliness.
2. Insufficient CMR.	a. Improper shielding of amplifier input circuit.	a. Check that test fixture shield is in place and properly driven by CMV.
	b. CMRA, CMA loop, feedback bridge, or gain option faulty.	b. Check these circuits for proper voltages, check components. With CMV applied, check that the Ref output of CMRA (shown as "OV" on detailed schematic) tracks CMV closely.
3. Erroneous gain:		
a. On all gain steps.	a. Defective resistor on gain options (R103 through R115).	a. Check values and connections.
b. During low frequency check.	b. GAIN ADJ control.	b. Check for proper setting, check trimmer (R104 or R110) for an open.
c. During high frequency check.	c. Inaccurate comparison against 100 cps gain. Test setup incorrect.	c. Recheck 100 cps gain, it should be relative to 2kc gain ±1% (see NOTE para. 5.4.4). Check test setup.
	d. Low loop gain.	d. Use ohmmeter to check connections and resistor values.

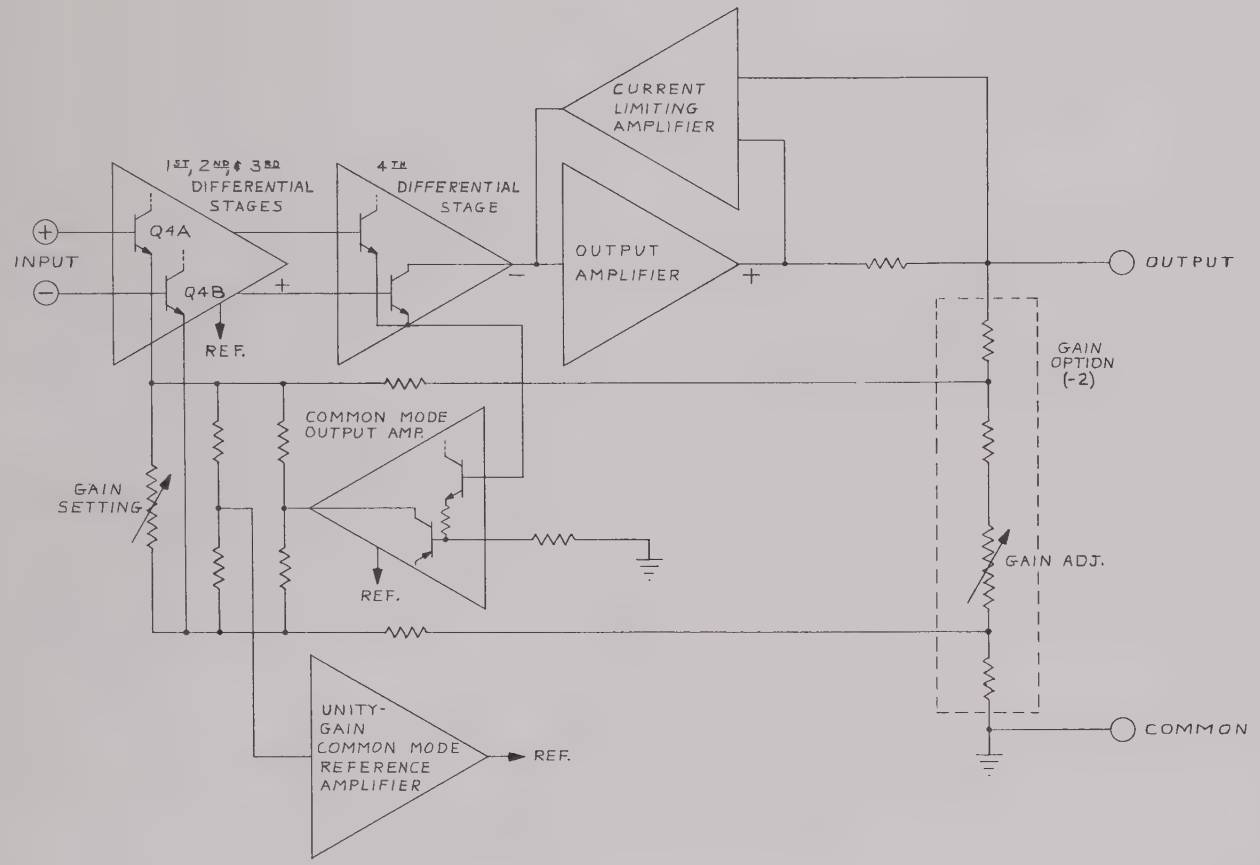
Table 5.3 Troubleshooting Guide (Continued)

Symptom	Probable Cause	Suggested Remedy
3. c. (Cont'd)	e. Faulty input connection – resulting in high source impedance.	e. Check input connection with ohmmeter.
4. Insufficient bandwidth.	a. Low loop gain.	a. See step 3. d.
	b. Accidental loading output with a high capacitance or high impedance input source from bad connection.	b. Check test setup.
	c. Output level too high.	c. Check for 0.75V rms as indicated in para. 5.4.5c.
5. Low Output.	a. Defective ±18V supply.	a. Check for full wave rectification, approx. 1V p-p ripple when A20B output is max, use ohmmeter to check Q21 through Q24 on MAB, check DC voltages in output section.
	b. AC line voltage too low.	b. Check AC line with 2% meter.
	c. Defective current limiting.	c. See step 6.
	d. Incorrect load (R_L) in test setup.	d. R_L should be 100 ohms ±5%, see figure 5.5.
6. Improper current limiting, limit as seen in para. 5.4.6c(3) less than 2.3V or more than 2.8V.	a. ± limiters defective.	a. Check Q25 through Q31, CR24 through CR29, and all resistors in CLA.
	b. Defective transistors in output section.	b. Check Q18 through Q24 and all associated components. Check voltages with no applied signal and then with limiting signal for indication of likely trouble area.

Table 5.3 Troubleshooting Guide (Continued)

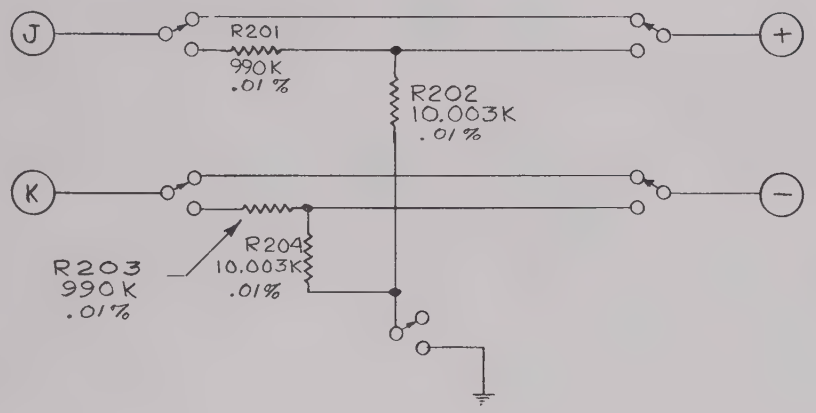
Symptom	Probable Cause	Suggested Remedy
7. Amplifier output zero on all gain settings.	a. No power. b. Defective output switch and associated wiring.	a. Check connector and fuse. b. Check S1C and all lines to and from it for opens or shorts to common.
8. A20B output excessive (high pos or neg) on all gain settings.	a. Open or shorted transistor.	a. Start at output and work toward input checking all transistors with ohmmeter. Use isolation procedure in para. 5.5.4.
9. A20B output oscillates at rate other than 60 cps or 120 cps.	a. Defective stabilizing element. b. Broken wire between board assemblies or on a cable.	a. Check for open lead on C7, C8, or C16. b. Make visual inspection and continuity checks.
10. Gain error on a single gain setting.	a. Defective gain resistor switch contact on S1A.	a. Use precision bridge or digital ohmmeter to check with one switch lead removed.


PRE-AMPLIFIER SECTION
OUTPUT AMPLIFIER SECTION
'OFFSET'
R50 10K
+30V
+23V
+6.2V
≈+2.2V
≈0V
+0.65V
-0.65V
MATCHED TO .1%
MATCHED SET
-1.7V
+4.4V
+1.2V
+3.8V
+1V
-23V
-30V
+6.8V
+6.2
+4.4
+1.2
+0.65
-0.65
-1.7
-23
-30
+1.9
+22.9
+22.4
+23
+16.5
-15.8
-16
+28.5
+28.6
+29.1
-22.8
-23V FROM OUTPUT AMP
-30V. COMMON GND. PLANE
ALL PREAMP COMMONS
TO COMMON GND PLANE
ALL OUTPUT AMP. COMMONS
COMMON GND PLANE
POWER SUPPLY SECTION
50MV
18V
13V
1V
-18V. +18V.
TO GAIN OPTIONS
GAIN OPTIONS
'GAIN ADJUST'
SIC
AUX. COMMON
OUTPUT LO
OUTPUT HI
COMMON GND. PLANE
LINE LO
LINE HI
GROUND
CHASSIS
KEY
AUX. COM.
OUTPUT LO
OUTPUT HI
GUARD
+ INPUT
- INPUT
117 VAC
230 VAC
117VAC
CASE
CHASSIS
TO GAIN OPTION
S1A
S1B
X1000
R19 THRU R24 .025%
507 . 2N11 >
NOTES: UNLESS OTHERWISE SPECIFIED -
1 ALL DIODES ARE IN456 OR E.I. 581
2. ALL RESISTORS ARE ¼W 5% CARBON.
3 ALL 1% RESISTORS ARE RN60E.
4 ALL CAPACITORS 10% (EXCEPT ELECTROLYTICS)
5. TEST SELECTED VALUE.
6 ALL NPN TRANSISTORS ARE 2N3391.
7. NOMINALLY INSTALLED VALUE, MAY BE ADJUSTED IN TEST.
8. NPN TRANSISTORS CALLED OUT AS '53' ARE 2N3053
9 ALL VOLTAGES ARE FOR NOMINAL LINE (117 OR 230V), AMPLIFIER INPUT SHORTED AND RETURNED TO OUTPUT LOW (E), ANY GAIN SETTING, AND ARE RELATIVE TO COMMON.
10. WHEN BUILDING A20B-34 (ONLY) REMOVE R105 - 649Ω 1% & REPLACE WITH R105 - 500Ω 1%
AMPLIFIER, D.C., DIFFERENTIAL
A20B
NONE
SCHEMATIC
SHT. 1 OF 3
520-112



TITLE: BLOCK DIAGRAM A20B	
MATERIAL:	
FINISH:	
TOOL:	SCALE:
NEXT ASSY.	TYPE: SCHEMATIC
SHT. 2 OF 3	DWG. NO.: 520-112 REV: (85)

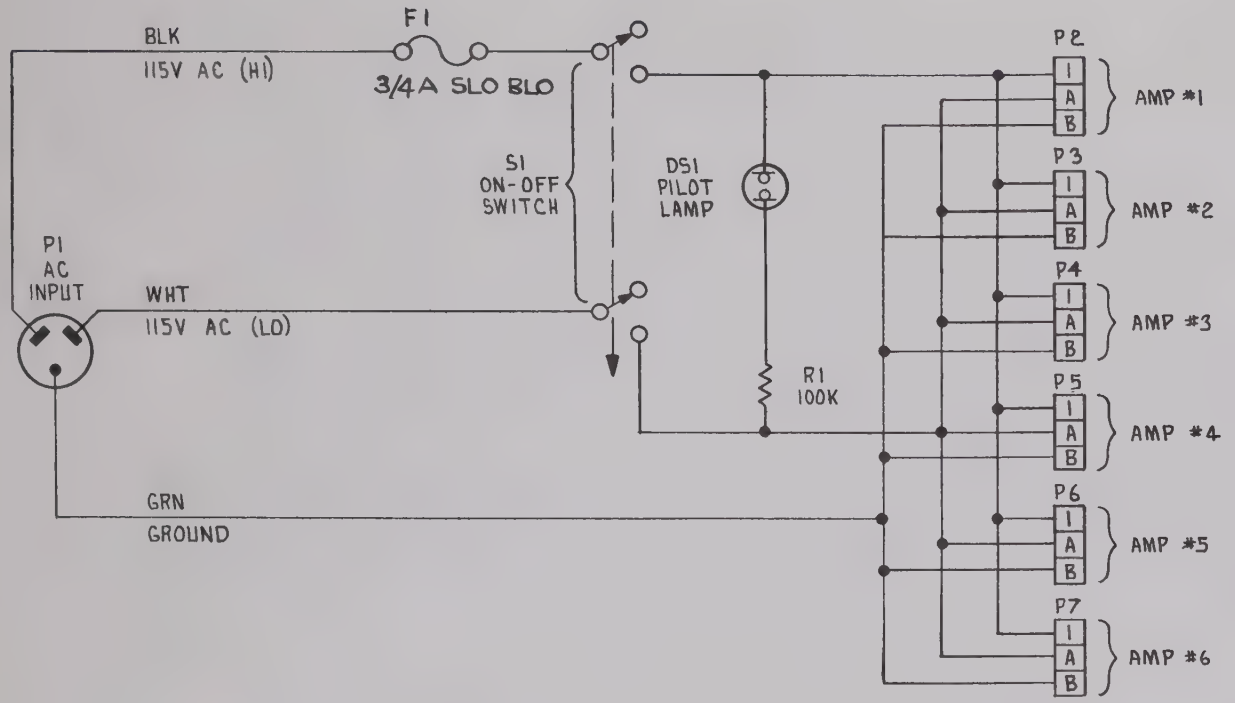
S-2



NOTES:

TITLE			
AMPLIFIER, D.C. DIFF. A20 B			
CODE IDENT NO. 00116	SIZE B	DRAWING NO. 520-112-(85)	REV
SCALE ——	WEIGHT	SHEET 3 OF 3	

04-383-075



TITLE	(A-20) RACK WIRING
MATERIAL	
FINISH	
TOOL	SCALE NONE
NEXT ASSY. 520-903-60	TYPE SCHEMATIC
SHT. 1 OF 1	DWG. NO. 520-903 DASH (81)

HONEYWELL
INC.

WARRANTY

The Company warrants all equipment manufactured by it and bearing its name plate to be free from defects in workmanship and material, under normal use and service, as follows: (a) equipment not installed by the company which (i) is returned to the Company's originating factory within 12 months after date of shipment, and (ii) is found by the Company's inspection to be defective in workmanship or material, will be repaired or replaced free of charge and returned—shipped lowest-cost transportation prepaid; and (b) equipment installed by the Company which is within 12 months after date of installation by the Company found by the Company's inspection to be defective in workmanship or material, will be repaired or replaced free of charge. If inspection by the Company does not disclose any defect in workmanship or material, the Company's regular charges will apply. Items specifically excluded from the 12 month warranty and which will not be repaired or replaced free of charge include flash tubes, galvanometer lamps, indicating galvanometer suspensions, choppers, tubes, fuses, batteries and similar components subject to wear or burn-out through usage. Warranty on tape heads is limited to 90 days. All statutory and implied warranties, except of title, are negative and excluded. The foregoing provisions are in lieu of all other warranties, guarantees, obligations or liabilities on the part of the Company. The Company shall not be liable for and the purchaser assumes and will indemnify and save harmless the Company in respect to any loss or damage that may arise through the use by the purchaser or others of any of the equipment.

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